Adventures Beyond Reductionism: The Remarkable Manifesto of Complex Holism

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Abstract

"If it could be demonstrated that any complex organ existed, which could not possibly have been formed by numerous successive, slight modifications, my theory would absolutely break down". Can Darwinian random mutations and selection generate biological complexity and holism? In this paper we argue that the "wonderful but not enough" tools of linear reductionism cannot lead to chaos and hence to complexity and holism, but with ChaNoXity this seems indeed plausible, even likely. Based on the Pump-Engine realism of mutually interacting supply and demand — demand institutes supply that fuels demand — we demonstrate that the "supply" of symmetry breaking Darwinian genetic variation, in direct conflict with the symmetry inducing "demand" of natural selection, defines the antagonistic arrows of the real and negative worlds. Working in this competitively collaborating nonlinear mode, these opposites generate the homeostasy of holistic life. Protein folding, mitosis, meiosis, hydrophobicity and other ingredients have their respective expressions in this paradigm; nucleotide substitution, gene duplication-divergence, HGT, stress-induced mutations, antibiotic resistance, Lamarckism would appear to fit in naturally in this complexity paradigm defined through emergence of novelty and self-organization.

With obvious departures from mainstream reductionism, this can have far reaching implications in the Darwinian and nano medicine of genetic diseases and disorders.

Our goal is to chart a roadmap of adventure beyond (neo)-Darwinian reductionism.

Keywords: Chanoxity; Reductionism; Darwinian Holism; Self-organization and Emergence; Demand, Supply, Logistic.

1   Introduction: Beyond Reductionism

Biological systems are complex holistic systems: thermodynamically open and far-from-equilibrium, self organizing, emergent. The normal tools of Newtonian analysis structured around linear reductionism fail to address these issues, just as classical Newtonian mechanics failed to embrace the microscopic, necessitating the quantum revolution 100 years ago. The "inadequate" reductionist tools of linear mathematics, where a composite whole is diagnosed as a sum of its parts, work so long as its foundational "normal", isolated, near-equilibrium — rather than "extreme"/"revolutionary", open, far-from-equilibrium — conditions are met. Increasingly, it is being felt that most of the important manifestations of nature and life display holistic behaviour which is the philosophy that parts of a whole cannot exist and be understood except in the context of the entirety: wholes generate interdependent, interacting, effects that are qualitatively different from what can be induced by the parts on their own. Complex self-organizing systems evolve on emergent feedback mechanisms and processes that "interact with themselves and produce themselves from themselves", they are "more than the sum of their parts". Holism simply put, is the thesis that parts of a whole cannot exist and be understood except in their relation to the whole; complex systems cannot dismantle into their parts without destroying themselves. The cybernetic system being analysed is involved in a closed loop where action by the system causes some change in its environment and that change is fed to the system via feedback information that causes the system to adapt to these new conditions — the system's changes affect its behavior. This "circular causal" relationship is necessary and sufficient for the cybernetic perspective of competitive-collaboration that forms the basis of life in Nature.

A remarkable example of the *competitive-collaboration* of the parts is the open source/free software dialectics, developed essentially by an independent, dispersed community of individuals. Wikipedia as an exceptional phenomenon of this collaboration, along with the Linux operating system, are noteworthy manifestations of the power and reality of self-organizing emergent systems: the "dependencies" of software

packages — that are depended on by others — and the resulting entangled web in its totality comprising the success of the system. How are these bottom-up community expressions of "peer-reviewed science" — with bugs, security holes, and deviations from standards having to pass through peer-review evaluation of the system (author) in dynamic equilibrium of competitive-collaboration with the reviewing environment — able to "outperform a stupendously rich company that can afford to employ very smart people and give them all the resources they need? Here is a posible answer: Complexity. Open source is a way of building complex things" [33], not orchestrated in the main, by any super-intelligence.

(Neo)Darwinian microevolution defined as change in allele frequencies, is a two-step, mutually independent linear reductionist process of any genetic change small or large in a population inherited over several generations. For an event to be considered evolutionary, changes have to occur at the genetic level of a population and be passed on from one generation to the next. This means that the genes, or more precisely, the alleles in the population change and are passed on through the phenotypes of the population. The first stage of symmetry breaking, random, infinitely small, heritable mutations of genetic variations, is followed by symmetry generating natural selection of fixation of beneficial changes as its principal motive force: natural selection acts to preserve and accumulate minor advantageous genetic mutations. Darwinism is a linearly smooth, gradual, continuous process, bereft of "surprises" and "unpredictability". Can the Darwinian paradigm of variation-selection-retention explain complexity and holism: "If it could be demonstrated that any complex organ existed, which could not possibly have been formed by numerous, succesive slight modifications, my theory would absolutely break down" observed Darwin [8]. In reality, symmetry-inducing "demand" institutes a symmetry-breaking "supply" which in turn fuels the "demand" in a feedback, interacting loop, essential for complexity and holism [43, 44]: evolutionary pressures act on the whole organism, not on single genes, and genes can have different effects depending on the other genes present. "A gene is never visible to natural selection, and in the genotype, it is always in the context with other genes, and the interaction with those other genes make a particular gene either more favorable or less favorable" [31]. As in economic holism [42], this implies that the product of mutually antagonistic mutation and selection evolve in time generating complex, emergent structures. Somatic mutation, sexual genetic recombination, gene flow and horizontal gene transfer increase variation while natural selection and random genetic drift decrease available free energy (exergy) that represents the "price"/"cost" of maintaining the bi-directional feedback mechanism of complexity and "life". Biological evolution also includes macroevolution of all life being connected that can be traced back to one common ancestor. In this work we are principally concerned with the foundations of microevolution.

Nature abhors gradients: according to the Second Law when a system is displaced from thermodynamic equilibrium, Nature tries to restore it by destroying the gradient. For large departures, if the system is unable to return to the old configuration, a new steady equilibrium state is sought by more efficient management through pattern formation of emergent phenomena and structures characteristic of complexity. Symmetry breaking, in particular breaking of equivalences leading to partitioning of the space, is Nature's way of introducing patterns, structures and complexity in an originally structureless and symmetric system. Symmetry and equivalence-breaking phase transitions is how Nature emerges holistically via nonlinear competitive-collaboration, *not* by adopting alternative evolutionary bifurcating routes linearly.

What lies beyond reductionism, at the heart of complex holism? The emergence of complex systems invalidates reductionist approaches in the understanding of open, far-from-equilibrium, hierarchical systems. Nonlinear complexity does not, however, violate any of the familiar reductionist analytic tools, applicable in their respective linear domains: for neighbouring or contiguous hierarchical levels, a reductionist approach can be expected to provide meaningful results. Thermodynamic expansion and long-range gravitational contraction obeying the virial theorem generate bi-directional positive-negative feedback loops of negative (absolute) temperatures, specific heat, entropy and distances in the black hole [42]. Its manifestation of gravitational attraction institutes the immunity of survival against eventual second-law entropic implosive cold death.

Darwin's theory of natural selection[1] states that if there are (i) variation and variety in a given population in an environment, (ii) differential reproduction and survival of individual members of the new generation, and (iii) inheritance of this variation by the next generation with *random* modifications, then evolution by natural selection follows with the new generation, more adapted to the environment, passing on its characteristics to the next. The central idea is that a species evolves because natural selection acts on small heritable variations in the members of the species: those adapting better to their environment tend to leave more progeny and transmit their characters, while those less able to adapt leave fewer progeny or die out, so that in the course of generations there is a progressive tendency in the species to a greater degree of adaptation.

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[1]For a spirited dissection of the inadequacies of Darwinism and Neo-Darwinism see Carsten Herrmann-Pillath, *The Concept of Information and the Problem of Holism Vs. Atomism in Biological and Economic Uses of Universal Darwinism* (August 24, 2007) at SSRN: http://ssrn.com/abstract=1009787. *Universal Darwinism* refers to any of several concepts which apply the ideas and theories of Darwinism beyond their original scope of organic evolution on Earth.

The genotype or genome, the genetic constitution in every cell of the organism, is the storehouse of the genetic blueprint in the DNA. Phenotype, the characteristics manifested by an organism, is the end product created by the organism that emerges through execution of the instructions in the genotype and is subjected to the battle for survival; the genotype, however, is the storehouse of accumulated evolutionary benefits of succeeding generations. The phenotypes compete, and the fittest among them have a higher chance of exchanging genes among themselves.

Neo-Darwinism, the modern version of Darwinism, is a synthesis of genetics and Darwinism: genetics provided the key insight into the means of transmittal of genetic information from one generation to the next responsible for variations. Neo-Darwinism postulates that natural selection acts on the heritable genetic variations in alleles of genes in populations, ultimately caused by variation in the order of bases in the nucleotides in genes. Mutations (especially random copying errors in DNA) mainly contribute to these genetic variations, the raw material for natural selection. Since genetic characteristics are not entirely identical among individuals in a population, genes of individuals with characteristics that enable them to reproduce successfully tend to survive at the expense of genes that tend to fail. This feature of *natural selection at the gene level* with consequences at the organism or *phenotype level*, is not a random process. Gene flow — the movement of genes from one population to another — is another important contributor to genetic variation, and sexual recombination of chromosomes leading to independent assortment of new gene combinations into a population is a third source of genetic variation.

2 Nonlocality, Entanglement and Holism. The Transactional Interpretation of Quantum Mechanics [6]

✪ *An experiment is an active intervention into the course of Nature. We set up this or that experiment to see how Nature reacts. If from such a description we can further distill a model of a free-standing "reality" independent of our interventions then so much the better. Classical physics is the ultimate example of such a model. However, there is no logical necessity for a realistic worldview to always be obtainable. If the world is such that we can never identify a reality independent of our experimental activity, then we must be prepared for that, too.*
Fuchs and Peres [14]

✪ *It has been suggested that quantum phenomena exhibit a characteristic holism or nonseparability, and that this distinguishes quantum from classical physics. The puzzling statistics that arise from measurements on entangled quantum systems demonstrate, or are explicable in terms of, holism or nonseparability rather than any problematic action at a distance.*
Stanford Encyclopedia of Philosophy

In the stressed, far-from-equilibrium, "revolutionary" world of today, the inadequate tools of normal science appear to have indeed run their course. As it had in the classical-quantum transition some 100 years back. Today, however, the hazards are far greater, the reductionism-holism revolution being more fundamental, with reductionism possibly a first-order linear representation of holism. We are clearly "horribly stuck" in almost all facets of human endeavour — cultural, social, political — with little understanding of what might possibly be behind this monumental betrayal.

The single most distinguishing feature of quantum from classical is the notion of *nonlocality*. Quantum nonlocality embodies the paradox of quantum entanglement in which measurements on spatially separated quantum systems instantaneously influence each other violating local realism, the philosophy that changes in one physical system can have no immediate effect on another spatially separated system. This "local realistic" view of nature asserts that events separated in time and space can be correlated at most through speed-of-light contact — no influence can travel faster than this maximum. Quantum nonlocality implies that these foundations of classical Newtonian physics are not inviolable, that there is a principle of holistic, faster-than-light, interconnectedness across spacelike or *negative timelike* intervals.

The mathematical formalism of quantum mechanics has not faced any serious challenge since its inception, although its interpretation continues to remain shrouded in mystery and dogged by controversy. Nonlocality, the paradoxical source of this mystery, puzzles rationality. Various *interpretations* of quantum mechanics have been advanced to understand this famous EPR paradox of which the *Copenhagen Interpretation* is admittedly the most well-known. According to this doctrine, $\Psi(r,t)$ is a mathematical representation of "our knowledge of the system" manifested through the measurement

$$\langle O \rangle = \int \Psi O \Psi^* d\tau. \tag{1}$$

This is the only admissible exposition of the physical significance of the retarted solutions $\Psi(r,t) \simeq e^{i(kr-\omega t)}$ of positive energy of the Schrodinger Equation to the future, $\Psi^*(r,t) \simeq e^{-i(kr-\omega t)}$ being the advanced solutions of negative energy to the past, of the complex conjugate time-reversed equation. Copenhagen interpretation admits no other significance to the state vector $|\Psi\rangle$; specifically contrary to normal usage *it is not a physically functional entity of space and time,* it is rather an encoded mathematical message of our knowledge of nature. In the *collapse* of $|\Psi\rangle$ following a measurement process, the implied change must occur simultaneously at all locations described by the state vector at that instant: a physical wave would necessitate instantaneous transmission if the "knowledge" alternative were to be abandoned.

Decoherence [37] the mechanism by which open quantum systems interact with their environment leading to spontaneous suppression of interference and appearance of classicality — utilized principally to explain the measurement problem involving transition from the quantum world of superpositions to the definiteness of the classical objectivity — partial tracing over the environment of the total density operator produces an "environment selected" basis in which the reduced density is diagonal. This irreversible decay of the off-diagonal terms is the basis of decoherence that effectively bypasses "collapse" of the state on measurement to one of its eigenstates. This "derivation of the classical world from quantum-mechanical principles" however only succeeds in bypassing the real issue because the non-diagonal terms are specifically responsible for heterozygosity and non-locality; this is to be compared with nonlinearly-induced emergence of complex patterns and structures through the multifunctional graphical convergence route [40]. Multiplicities inherent in this mode, liberated from the strictures of linear superposition and reductionism, allow interpretation of objectivity and definiteness as in classical probabilistic systems through a judicious application of the axiom of choice: to define a choice function is to conduct an experiment, [44].

The above relationship of Ψ and Ψ^* leads to the of the *Transactional Interpretation* [6] in which the retarded, physical *offer wave* from an emitter elicits an advanced, physical *confirmation wave* from the absorber, interacting with each other to complete the "handshake" *transaction* of an explicitly nonlocal character. The future absorber influencing the past emitter focuses on the *compound of "knowledge" and "ignorance".* According to Cramer[6] "The root of the (non-transactional) inconsistencies lies in the implicit assumption of Copenhagen interpretation that the state vector collapse occurs at a particular instant at which a particular measurement is made and 'knowledge' is gained, that before this instant the state vector is in its full uncollapsed state, and that there can be a well-defined 'before' and 'after' in the collapse description. In the transactional interpretation the collapse of the development of the transaction, is atemporal and thus avoids the contradictions and inconsistencies implicit in any time-localized state-vector collapse."

The Copenhagen interpretation (1) regards quantum mechanics to be intrinsically about awareness, observations, and measurements emanating from a unitary evolution of the Schrodinger equation with little on what it is ontologically or what infact it seeks to describe. According to this philosophy, the wavefunction is simply an auxiliary mathematical tool devoid of any physical significance, whose only import lies in its ability to generate the probabilities $\Psi^*\Psi$ compactly, representing our knowledge of the preparation and subsequent evolution of a physical system; only experimental results lie in the perview of physical theories and ontological questions are invalid. The $|\Psi\rangle$ function has only a "symbolic" significance in associating expectation values with dynamic variables and does not represent anything real, the imaginary component in the state variable forbidding a pictorial represention of the real world. The dynamics of the Schrodinger equation describes how the observer's knowledge of the system changes as a function of time.

Quantum nonlocality is technically expressed in terms of *entanglement.* Any

$$|\Psi\rangle_{SE} = \sum_{i,j} \alpha_{ij} |\phi_i\rangle \otimes |\psi_j\rangle$$

in the tensor product space $\mathcal{H}_S \otimes \mathcal{H}_E$ that cannot be factored as a product of its component parts $\{|\phi_i\rangle\} \in \mathcal{H}_S$ and $\{|\psi_j\rangle\} \in \mathcal{H}_E$, that is $|\Psi\rangle_{SE} \neq |\phi\rangle \otimes |\psi\rangle$), is said to be **entangled** (nonlocal); $|\Psi\rangle_{SE}$ is **unentangled** (separable) if it is factorisable into the components. Thus, choose orthonormal bases $\{|\uparrow\rangle_S, |\downarrow\rangle_S\}$ and $\{|\uparrow\rangle_E, |\downarrow\rangle_E\}$ in $\mathcal{H}_S$ and $\mathcal{H}_E$ so that $\mathcal{H}_{SE}$ is spanned by the vectors $|\uparrow\rangle_S |\uparrow\rangle_E$, $|\uparrow\rangle_S |\downarrow\rangle_E$, $|\downarrow\rangle_S |\uparrow\rangle_E$, and $|\downarrow\rangle_S |\downarrow\rangle_E$. Then for the qubits [2] $|\Phi\rangle_S = \sigma_1 |\uparrow\rangle_S + \sigma_2 |\downarrow\rangle_S$ and $|\Upsilon\rangle_E = \varepsilon_1 |\uparrow\rangle_E + \varepsilon_2 |\downarrow\rangle_E$

$$
\begin{aligned}
|\Psi\rangle_{SE} &= \sigma_1\varepsilon_1 |\uparrow\uparrow\rangle + \sigma_1\varepsilon_2 |\uparrow\downarrow\rangle + \sigma_2\varepsilon_1 |\downarrow\uparrow\rangle + \sigma_2\varepsilon_2 |\downarrow\downarrow\rangle \\
&= |\Phi\rangle_S \otimes |\Upsilon\rangle_E
\end{aligned}
\tag{2a}
$$

is a separable state, whereas

$$|\Phi_\pm\rangle_{SE} = \alpha_1 |\uparrow\uparrow\rangle \pm \alpha_2 |\downarrow\downarrow\rangle \neq |\Phi\rangle_S \otimes |\Upsilon\rangle_E \tag{2b}$$

$$|\Psi_\pm\rangle_{SE} = \beta_1 |\uparrow\downarrow\rangle \pm \beta_2 |\downarrow\uparrow\rangle \neq |\Phi\rangle_S \otimes |\Upsilon\rangle_E \tag{2c}$$

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[2]Unlike a classical bit which must be either of the two possible values "on" $|\uparrow\rangle$ or "off" $|\downarrow\rangle$, the *qu*(antum)*bit* can be either $|\uparrow\rangle$, or $|\downarrow\rangle$, or a superposition $\alpha |\uparrow\rangle + \beta |\downarrow\rangle$ (with $\alpha^2 + \beta^2 = 1$) of both in the two-dimensional Hilbert space spanned by $|\uparrow\rangle$ and $|\downarrow\rangle$.

are nonseparable, entangled, Bell states.[3]

An entangled state does not define vectors in the individual factor spaces $\mathcal{H}_S$ and $\mathcal{H}_E$ unless the state is actually unentangled. For physically separated S and E, a measurement outcome of $|\uparrow\rangle$ on S implies that any subsequent measurement on E in the same basis will always yield $|\uparrow\rangle$. If $|\downarrow\rangle$ occurs in S, then E will be guaranteed to return $|\downarrow\rangle$; hence system $|E\rangle$ has been altered by local random operations on $|S\rangle$. This non-local puzzle of entangled quantum states — the orthodox Copenhagen doctrine maintains that neither of the particles possess any definite position or momentum before they are measured — is resolved by bestowing quantum mechanics with non-local properties determined by Bell's inequality. In this sense entanglements induced by *iterations* of nonlinear *separable* systems like the generalized logistic qubit of the product of supply ($\downarrow$) and demand ($\uparrow$) functions (see Sec. 5), are destined to be far more complex than that of the partial Bell states Eqs. (2b, c).

3   ChaNoXity: Pump-Engine Realism of the Participatory Universe [42]

✪ *Let us see how we humans use the second law for our purposes. Whenever we run any kind of engine, we're using the second law for our benefit: Taking energy inside of substances that tend to spread out, but can't because of (the activation energy) E_a, giving it the necessary energy, having the diffusing energy in the form of hot expanding gases push a piston that turns crankshafts, gears and wheels, with the exhaust gases, still fairly hot, but no longer available for any more piston-pushing in this engine. Did we beat the second law? No way. But by using the second law — taking the energy from spontaneous "downhill" reactions and transferring much of it to force a nonspontaneous process to go "uphill" energy-wise and make something — we got what we wanted.* ⋯
Living creatures are essentially energy processing systems that cannot function unless a multitude of "molecular machines", biochemical cycles, operate synchronically in using energy to oppose second law predictions. All of the thousands of biochemical systems that run our bodies are maintained and regulated by feedback subsystems, many composed of complex substances. Most of the compounds in the feedback systems are also synthesized internally by thermodynamically nonspontaneous reactions, effected by utilizing energy ultimately transferred from the metabolism of food. When these feedback subsystems fail — due to inadequate energy inflow, malfunction from critical errors in synthesis, the presence of toxins or competing agents such as bacteria or viruses — dysfunction, illness, or death results: energy can no longer be processed to carry out the many reactions we need for life that are contrary to the direction predicted by the second law.
                                                                            Lambert [26]

3.1   The Logistic Nonlinear Qubit: competitive-collaboration of Supply and Demand

The logistic difference equation $x_{t+1} = \lambda x_t (1-x_t)$ representing nonlinear interaction between individualistic supply x and collaborative demand $1-x$ is the starting point in our study of complexity and holism, [41, 42, 43, 44], with λ is an environment parameter. In the context of population dynamics λ referring to "an intrinsic reproductive rate of the average fecundity of an individual" [4] corresponds to the *mean fitness* of the organism; here fecundity is the number of gametes and progeny zygotes produced by the parents surviving to adulthood. The gametic lifecycle of sexually reproduced organisms with differential survival and reproduction of genotypes leading to selection can then be summarized as follows [16]

It is asumed that in the absence of limiting factors, λx the population in a succeeding generation, is the positive feedback that is effectively regulated by the negative feedback of depletions $(1-x)$: the zygotic transformation $t \mapsto t+1$ corresponds to the logistic map.

The adversaries *individualistic supply* and *collectivistic demand* collaborate nonlinearly to generate life in a win-win game where no participant wins and none lose. This self-organizing, emergent system working on a positive-negative bi-directional $\rightleftarrows$ feedback loop, adjusts itself to the environmental conditions it finds itself in leading to a homeostasis of "inevitable limitations, compromises and trade-offs" that neither of the participants, working alone and independently, can achieve. Both adversaries have equal stake in the complexity of holistic life and participate as equal partners, each competing with its opponent for its own collaborative good. In this capital-culture contest [42] of self-organization and emergence, one of the contestants assumes a dissipative passive (recessive) role of an "offerer" that elicits an active "confirmation" from a concentrating (dominant) opponent leading to a handshake "transaction" of an explicitly non-local character: the cause and effect entangle in generating a two-phase complex mixture, with the bottlenecked life-cycle making "possible the equivalent of going back to the drawing board" because "really radical changes can be achieved

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[3]A 2-qubit state is separable iff $ad = bc$ for $|\Psi\rangle = a\,|\uparrow\uparrow\rangle + b\,|\uparrow\downarrow\rangle + c\,|\downarrow\uparrow\rangle + d\,|\downarrow\downarrow\rangle$.

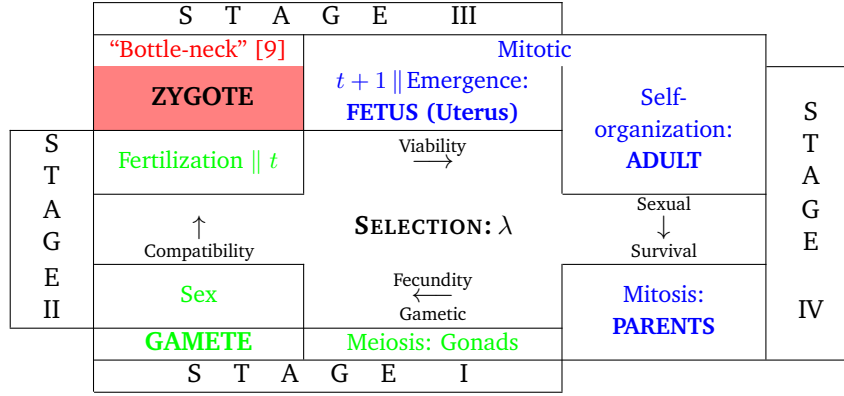|	STAGE III			
	"Bottle-neck" [9]	Mitotic		
STAGE II	**ZYGOTE**	$t+1 \,\|\,$ Emergence: **FETUS (Uterus)**	Self-organization: **ADULT**	**STAGE IV**
	Fertilization $\|\, t$	Viability $\longrightarrow$		
	$\uparrow$ Compatibility	**SELECTION:** λ	Sexual $\downarrow$ Survival	
	Sex	Fecundity $\longleftarrow$ Gametic	**Mitosis: PARENTS**	
	GAMETE	**Meiosis: Gonads**		
	STAGE I			

Table 1a: Gametic life-cycle of organisms. The basic characteristic that distinguishes meiosis from mitosis is the cross-over of homologous chromosomes resulting in the production of sperm and egg in the gonads. The cycle can be sequenced into four steps leading to the notion of an *extended meiosis* represented by Stages I, II and III of meiotic gonads to mitotic emergence, Sec. 4.3.

only by throwing away the previous design and starting afresh". The replicating concentrator uses the offerer as a vehicular "tool by which it levers itself into the next generation" [9]: it needs the vehicle not only to express itself meaningfully and purposefully despite its bewildering multitude of interactive interactions, more importantly the finite and complicated nature of the vehicle acts as a necessary physical impediment in inhibiting the cancerous growth of uncontrolled replication, with the environment of an "extended phenotype" resolving the "paradox of the two ways of looking at life". Non-reductionist graphical convergence in an extended multifunctional space is almost a natural corollary to this unconventional view of the phenotype of the replicator-vehicle antagonistic collaboration embracing the unconventionality of HGT.

While biologic life is supply regulated depending principally on the resources available, an individualistic supply economy — like a non-democratic form of political governance — can lead to severe collective stresses. Working in the two-spin mode of individualism ($\downarrow$) and collectivism ($\uparrow$) represented respectively by the increasing-positive and decreasing-negative slopes of the logistic map, the feedback loop of self-organization and emergence achieve in one nonlinear step the dual functions of inducing the resource of scarce order in an universal backdrop of pervasive disorder. Thus if deaths were absent with only the ordering component x available, there would be no cutoff to the explosive growth of fitness; likewise with only $1-x$ present the vanishing unfit, steadily eroded through selection, would lead to the eventual extinction of the population.

The logistic map through its nonlinear handshake of these interactive opponents achieves the remarkably wondrous transaction of inclusive holism.

3.2 Alleles and Genotypes. Confrontation of Opposites: A Generalization

As the commentary in the preceding Section indicates quantum nonlocality, properly interpreted, shares with chanoxity the fundamental characteristic of collaboration between competing adversaries that defines holistic entanglement. We have however argued elsewhere [42, 43, 44], that quantum nonlocality and complex holism are not the same: quantum mechanics is a linear theory while complex chanoxity is violently nonlinear. In the linear setting, multipartite systems in 2^N-dimensional tensor products $\mathcal{H}_1 \otimes \cdots \otimes \mathcal{H}_N$ of 2-dimensional spin states, correspond to the 2^N dimensional space of unstable fixed points of chanoxity [41]. This formal equivalence while clearly demonstrating how holism emerges in 2^N-cycle complex systems, also focuses on the significant differences between complex holism and linear non-locality which can eventually be traced to the constraints imposed by reductionism, also Sec. 5.1. The converged holism of complex "entanglement" reflects the fact that the subsystems have combined nonlinearly to form an emergent, self-organized system that cannot be decoupled without destroying its structure; quantum nonlocality and the notion of partial tracing for obtaining properties of individual components from the whole is not restricted by this defining property of complex holism.

To establish the perspective of our considerations that follow, consider the iconic Mendel monohybrid and dihybrid pea-plant experiments as an example. The monohybrid case is summarized in the Punnett diagram of Fig. 1a: the alleles[4] **T** and **t** formally correspond to the "spin" strategies ($\downarrow$) and ($\uparrow$), and the genotypes of

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[4]**Alleles** are the alternate forms of the two genes of an organisms located on chromosomes that control each heritable characteristic or *trait,* one contributed by the female and the other by the male. When gametes develop during meiosis — a process of cell division that specifically produces the sex cells — each gamete receives only one of these alleles.

the entire set of genes in a cell, organism or individual, correspond to the respective stable states ●. Of the two alleles for every trait, we take the chromosome contributed by the female (**T**) in her ova as *dominant* and the male allele (**t**) in his sperm as *recessive*. Joined together in fertilization, there are thus three possible genotypes for each characteristic trait: **TT** homozygous dominant with **Tt/tT** heterozygous of the same phenotype, and **tt** homozygous recessive expressed in a different phenotype.

♂(↑) allele	$\mathbf{t}(0(↓))$	$\mathbf{t}(1(↑))$
♀(↓) allele		
$\mathbf{T}(0(↓))$	**Tt**	**Tt**
$\mathbf{T}(1(↑))$	**Tt**	**Tt**
Homozygous tall parents $\xrightarrow{F_1}$		
All heterozygous **Tt** tall daughters		
(a)		

♂(↑) allele	$\mathbf{T}(0(↓))$	$\mathbf{t}(1(↑))$
♀(↓) allele		
$\mathbf{T}(0(↓))$	**TT**	**Tt**
$\mathbf{t}(1(↑))$	**tT**	**tt**
Heterozygous tall parents $\xrightarrow{F_2}$		
1 **TT** tall, 2 **Tt** tall, 1 **tt** short		
daughters: $3:1$ ratio		
(b)		

Figure 1*a*: **Mendel and Meiosis - 1.** In this linear setting, the parental alleles **T** and **t** produce the only heterozygous genotypes **Tt** of tall plants which segregate into gametes with half carrying one of the allele and the other half the other allele, correspond to the nonlinear entanglements of 2^2 cycle. Note that (↓↓) is a Nash equilibrium. The three possible F_1 gamete genotypes — **TT** (homozygous dominant), **Tt** (heterozygous), and **tt** (homozygous recessive) — in $3:1$ ratio, arise from successful ♂ − ♀ mating.

Our use of the terms "dominant" and "recessive" for the female and male alleles in a diploid cell is at variance with the simplest form of allelic interaction formulated by Mendel where the phenotypic effect of one allele completely masks that of the other in heterozygous combinations when the phenotype produced by the two alleles is identical to that produced by the homozygous genotype of the dominant member. In the nonlinear case of holistic evolution regulated by interactive feedbacks between "demand" and "supply", the symmetry breaking, gravity-stimulated,[5] ordering supply-pump moderates the second law demand-engine of symmetry inducing dissipation, and dominance represents the overriding entropy modulation by the negative world $\mathfrak{W}$ on W manifested through the ordered structures of Nature, see Sec. 4.

The choice of the female — rather than the male — as the dominant of the complementary pair is based on our understanding that the uterus symbolizes the receptacle of biological order in mammals: it is here that the second law of dissipation appears to have been completely defeated by order-inducing gravitational coalescence with its roots in $\mathfrak{W}$. In this negative multifunctional dual where "anti-second law" requires heat to flow spontaneously from lower to higher temperatures with positive temperature gradient along increasing temperatures, the engine and pump interchange their roles with ordering compresssion of the system by the environment — rather than the entropic expansion against it of W — being the natural direction in $\mathfrak{W}$. This postulates the rather startling hypothesis that the female of a species is possibly the most significant direct link of W with its source of negativity anchored in $\mathfrak{W}$ — she is the "capital" supplier-in-adversary in competitive-collaboration of unity-in-diversity with male cultural demand.[6]

An observation of immense significance is that the diploid-cross matrix $\mathfrak{C}$ for two independent traits $\mathfrak{A}$ and $\mathfrak{B}$ is infact a tensor product of the monohybrid F1 matrices of Fig. 1*a*. Thus $\mathfrak{C} = \mathfrak{A} \otimes \mathfrak{B}$ in Fig. 1*b* for the $\mathfrak{A}$ and $\mathfrak{B}$ traits generates the product $\mathbf{AaBb} \otimes \mathbf{AaBb}$ of Fig. 1*c*, noting that the order of the alleles is immaterial here. This suggests a common base for quantum nonlocality and Mendelian inheritance which, as we have argued earlier [43, 44], is a linear representation of complex holism.

Newton and Darwin fundamentally constructed two different types of reductionist worlds. "Newton's universe was stationary, cycling without change through all eternity, perfectly knowable and completely

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[5]**Gravity** is the thermodynamic legacy of the negative world $\mathfrak{W}$ in W generating the characteristic dissipation-concentration, two-state (↑↓) signature of complexity and holism [42].

[6]"Capital" and "Culture" are technical terms introduced in [42].

Capital: A factor of production not significantly consumed, which is not wanted for itself but for its ability to help in producing other goods; any form of wealth capable of being employed in the production of more wealth. In a fundamental sense, capital consists of any produced thing that can enhance a person's power to perform useful work. http://en.wikipedia.org/wiki/Capital.

Capital is free-energy, exergy, information: the genotype of a multicellutar organism. On its own, capital is as insatiated as egg without sperm.

Culture: The set of shared attitudes, values, goals, and practices that characterizes an institution, organization or group; an integrated pattern of human knowledge, belief, and behavior that depends upon the capacity for symbolic thought and social learning. http://en.wikipedia.org/wiki/Culture.

According to Edward Tylor, culture "is that complex whole of knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society".

Culture the organism's phenotype, on its own is as impotent as sperm without egg.

𝔄	A	a		𝔅	B	b		AABB	AABb	AaBB	AaBb
A	AA	Aa	⊗	B	BB	Bb	=	AAbB	AAbb	AabB	Aabb
a	aA	aa		b	bB	bb		aABB	aABb	aaBB	aaBb
								aAbB	aAbb	aabB	aabb
									(c)		

Figure 1*b*: **Mendel and Meiosis - 2.** The diploid cross of two independent traits is the tensor product ⊗ of the individual traits. This suggests reductionist similarities with quantum entanglement in the organizational assembly of an increasing number of components into a composite whole. Taking $\mathfrak{A} = \mathfrak{B}$ as the valid tensor product of a matrix with itself, leads to the situation where each of the emergent periodic point homologous units like {**AAbb** ∥ **aAbb**} and {**AaBB** ∥ **aaBB**} of individual genotypes can be considered as organs of a particular trait. The $(3:1) \times (3:1)$ cross of $\mathfrak{A} \otimes \mathfrak{B}$ generates the degeneracy in the arrangement of alleles into 4 groups: (0000), $(0001, 0010, 0011)$, $(0100, 1000, 1100)$, and $(0101, 0110, 0111, 1001, 1101, 1010, 1011, 1110, 1111)$ corresponding to ♀ contributions of both traits from both parents, ♀ contributions of any one trait from both parents, and the remainder, leading to the classical 1:3:3:9 ratio of genotypes. Clearly, this follows the classical linear and reductionist sense of "dominant" and "recessive" traits in heterozygosity, with little intermingling as mandated in holism.

predictable. In Darwin's world, history mattered. The shape of the future depended on the outcome of past events. No elegent equations could predict the future of even a single organism, because chance itself is inherent in life. Newton and Darwin created two utterly different conceptions of Nature: one for lifeless objects, the other for living things; one for stability, the other for change" [36]. Nonetheless, it is not enough in life for effect to simply depend on cause; reciprocally cause is simultaneously influenced by the effect it produces. Advanced and retarded waves acting together in harmony defines reality, one without the other is incomplete as Eq. (1) and Eq. (3) below explicitly demonstrate.
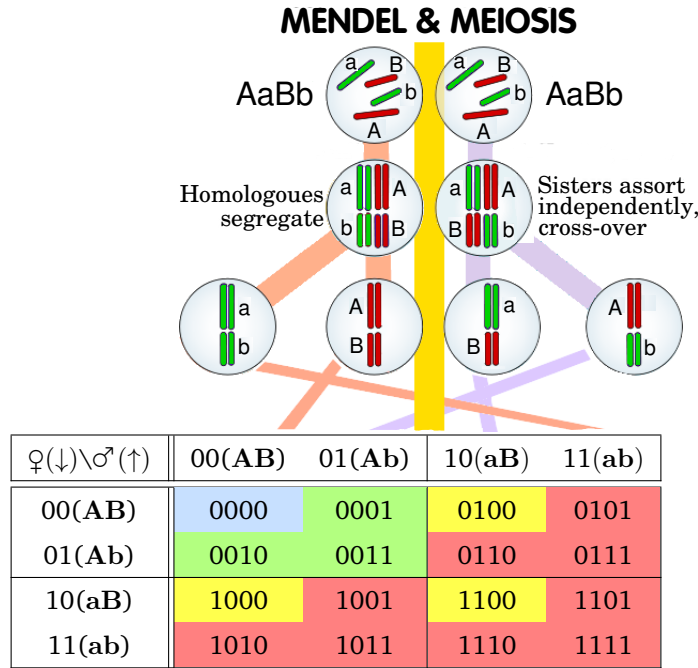

MENDEL & MEIOSIS

♀(↓)\♂(↑)	00(**AB**)	01(**Ab**)	10(**aB**)	11(**ab**)
00(**AB**)	0000	0001	0100	0101
01(**Ab**)	0010	0011	0110	0111
10(**aB**)	1000	1001	1100	1101
11(**ab**)	1010	1011	1110	1111

Figure 1*c*: **Mendel and Meiosis - 3.** The duplicated sister chromatids of Fig. 1*a* perform as "two independent traits" A, B with the traits in (a, b) and (A, B) "crossing over" to generate the Male-Female collaborations (↑,↓) of (a, B) and (↓,↑) of (A, b). Gamete compatibility of the traits lead to successful fusing of the gametes and formation of zygotes with genotypes shown.

4 Yang-Yinism of Darwinian Evolution

✪ *This (transactional) model describes any quantum event as a "handshake" executed through an exchange of advanced and retarded waves. Any emission process makes "advanced" waves* $e^{i\omega t}$ *on an equal*

basis with ordinary "retarded" waves $e^{-i\omega t}$. Both advanced and retarded waves are valid solutions of the electromagnetic wave equation, but in conventional electrodynamics the advanced solutions are rejected as unphysical or acausal. This advanced-retarded handshake is the basis for the transactional interpretation of quantum mechanics. It is a two-way contract between the future and the past. The transaction is explicitly nonlocal because the future is, in a limited way, affecting the past. **John J. Crammer** [6]

In the above we have advocated a unified framework for the evolutionary dynamics of Nature of which the linear depictions of quantum non-locality, biological Punnett squares, and economic payoffs and equilibria are different manifestations. Complexity results from the interaction between parts of a system such that it manifests properties not carried by, or dictated by, individual components: complexity resides in the interactive competitive-collaboration between the parts and the properties of a complex system are said to "emerge, without any guiding hand". Competitive-collaboration, as opposed to reductionism, in the context of this characterization means that the interdependent parts retain their individual attributes, with each contributing to the whole in its own characteristic fashion within a framework of dynamically emerging inclusive globality of the whole. Although the properties of the whole are generated by the parts, the individual units acting independently on their own cannot account for the collective behaviour of the total; a complex system is an assembly of many interdependent parts, interacting with each other through competitive nonlinear collaboration leading to self organized, emergent inclusiveness.

Our earlier contention [42, 43, 44] that *complex holism represents a stronger form of entanglement than quantum nonlocality* is further corroborated in the present study: Punnett squares and payoff matrices represent definite forms of equilibria although itertated prisoner's dilemma is often used as a pedagogical example of how collaboration emerges from confrontation. The 4×4 matrix of dihybrid cross continues to be meaningful for a single trait under tensor product $\mathfrak{R} \otimes \mathfrak{R}$ of $\mathfrak{R}$ with itself characterizing evolutionary iteration. The 9: 3: 3: 1 F_2 ratio is not evolutionary holistic, only a linear non-dynamic expression of this omnipresence.

Mathematically, inverse and direct limits denoted by $\varprojlim$ and $\varinjlim$ [11] constitute a rationale for the simultaneous existence opposing directional arrows that follow from very general considerations. Thus reality of the union of a family of nested sets entails the existence of their intersection, and conversely. In the context of Hilbert spaces, these limits taken together specialize to the extended rigged Hilbert space $\Psi \subset \mathcal{H} \subset \Psi^{\times}$

$$\underset{\leftarrow \text{ Entropy}}{\overset{\substack{\leftarrow \quad \text{Entropy decreasing} \\ \text{Replicator}}}{\varprojlim \mathcal{H}^k \triangleq \Psi = \bigcap_k \mathcal{H}^k \subset \cdots \subset \mathcal{H}^1}} \underset{\text{Competitive}(\downarrow)}{\subset \mathcal{H} \subset} \underset{\substack{\text{Entropy increasing} \\ \text{Interactor}}}{\overset{\substack{\text{Collaborative}(\uparrow) \qquad\qquad \text{Exergy} \rightarrow}}{\mathcal{H}_{-1} \subset \cdots \subset \bigcup_k \mathcal{H}_{-k} = \Psi^{\times} \triangleq \varinjlim \mathcal{H}_{-k}}} \tag{3}$$

with Ψ the space of physical states prepared in actual experiments and $\Psi^{\times}$ antilinear functionals on Ψ that associates with each state a real number interpreted as the result of measurements on the state — the spaces of test functions Ψ and distributions $\Psi^{\times}$ enlarge the Hilbert space $\mathcal{H}$ to the rigged space $(\Psi, \mathcal{H}, \Psi^{\times})$. If $\{X_k\}_{k \in \mathbb{Z}_+}$ is an increasing family of subsets of X and $\eta_{mn}: X_m \to X_n$ is the inclusion map for $m \leq n$, then $\varinjlim X_k = \bigcup X_k$ corresponds to the entropy decreasing direct iterates f^i of the logistic map; for $\{X^k\}_{k \in \mathbb{Z}_+}$ a decreasing family of subsets of X with $\pi^{nm}: X^n \to X^m$ the inclusion map, $\varprojlim X^k = \bigcap X^k$ represents the entropy increasing inverse iterates f^{-i}. As topological spaces, direct and inverse limits carry the final and initial topologies with respect to their respective canonical morphisms which are identified in Sec. 5. Equation (3) can be visualized as a pyramid with a direct $\varinjlim$ base of concentrative compression and an inverse $\varprojlim$ tip of dissipative expansion. The homeostasis $\mathcal{H}$ is a dynamical mixture of these extremes, with the entropy increasing engine acting in the domain of the pump to increase collective cooperation and the entropy decreasing pump operating in that of the engine to boost individual selfishness.

The forward and backward iterates of f collectively define graphical convergence leading to the multifunctional homeostasis [40] of nonlocality and entanglements reflecting limitations, compromises and trade-offs, Fig. 2*a, b*.

Both the Copenhagen interpretation Eq. (1) and transactional interpretation constitute illustrations of these limits.

4.1 Cohabitation of Opposites

Figure 2*a, b* summarizes our current understanding of complex holism. The fundamental issue is the existence of a negative world $\mathfrak{W}$ for every real world W as defined by

$$\mathfrak{W} \triangleq \{\mathfrak{w}: \{w\} \bigoplus \{\mathfrak{w}\} = \emptyset\}; \tag{4a}$$

$\mathfrak{W}$ is the negative, or exclusion, set of W[7]. Hence for all A $\subseteq$ W there is a neg(ative) set $\mathfrak{A} \subseteq \mathfrak{W}$ associated with (generated by) A that satisfies

$$A \bigoplus \mathfrak{G} \triangleq A - G, \quad G \leftrightarrow \mathfrak{G}$$
$$A \bigoplus \mathfrak{A} = \emptyset. \tag{4b}$$

The pair $(A, \mathfrak{A})$ act as relative discipliners of each other in "undoing", "controlling", "stabilizing" the other. This induces a state of dynamic homeostasis in W of limitations, compromises and trade-offs that permits out-of-equilibrium complex composites of a system and its environment to coexist despite the privileged omnipresence of the Second Law. The evolutionary process ceases when the opposing influences in W and its moderator $\mathfrak{W}$ balance. $\mathfrak{W}$ is the source of *all* creativity in W, that however can natively support only sterile dissipation: through the induction of gravity — its ordering signature — in W, the negative world $\mathfrak{W}$ is indeed the progenitor of Schroedinger's neg-entropy. On its own, capital is as destructively dissipative as its parent gravity, leading to the only eventuality of crashes and catastrophic heat death.
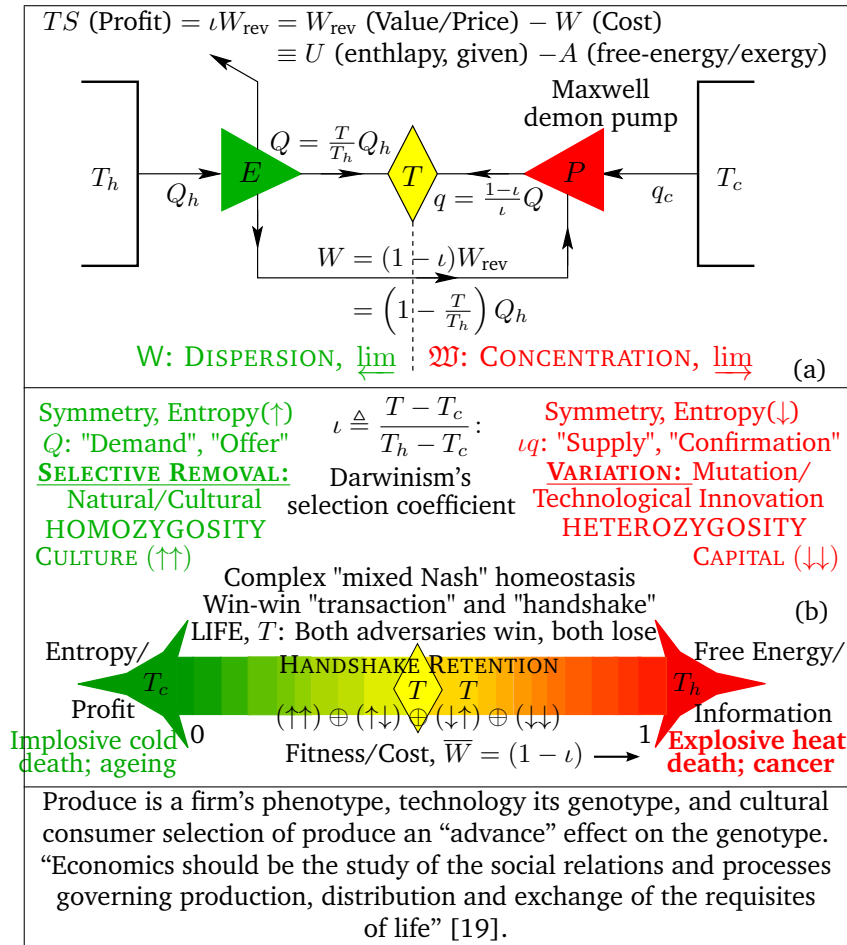

Figure 2a: **ChaNoXity — The New Science of Complex Holism [42]; Universal Darwinism [5].** Reduction of the dynamics of opposites to an equivalent Pump-Engine thermodynamic system; $W_{\text{rev}} = \eta_E Q_h$, $W(T) = \eta Q_h = \eta_E/(1 - \eta_E)Q = (T_h/T)\eta_E Q$, where $\eta_E = 1 - (T_v/T_h)$, $\eta = 1 - (T/T_h)$ are the thermodynamic efficiencies of the engine. The collaborative confrontation of $Q(T) \triangleq Q_h - W(T) = Q_h - [1 - \iota(T)]W_{\text{rev}} = (T/T_h)Q_h$ and $q(T) = [(1 - \iota(T))/\iota(T)]Q$, permits the interpretation of Q as "demand" that is met by the "supply" ιq in a bidirectional feedback loop that sustains, and is sustained by each other, in the context of the whole. The entangled characterization $(\uparrow\uparrow) \oplus (\uparrow\downarrow) \oplus (\downarrow\uparrow) \oplus (\downarrow\downarrow)$ of the holistic temperature T is to be compared with the non-locality of Eqs. (2a, b, c). Heterozygosity of an organism, as considered here, is a continuous parameter determined by the homeostasy of inheritance T.

This W$-\mathfrak{W}$ dualism is formalized in the Engine(W) $\leftrightarrow$ Pump($\mathfrak{W}$) bidirectional, positive-negative feedback of Fig. 2a. An *engine* E needs fuel to deliver; this is its "demand" in exchange for an "offer" of non-entropic, constructive, work. Complex systems achieve this by establishing an autocatalytic positive feedback process in the form of a *pump* P that counters the symmetrization of E though symmetry breaking and inducement of

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[7]Notice that this definition is meaningless if restricted to W or $\mathfrak{W}$ alone; it makes sense, in the manner defined here, only in relation to the pair (W, $\mathfrak{W}$).

FORWARD-INVERSE ARROW →	BACKWARD-DIRECT ARROW ←
W: Natural Selection	$\mathfrak{W}$: Somatic Mutation
Top-down Engine E	Bottom-up Pump P
Disorder: Entropy increasing	Order: Entropy decreasing
Dissipative: Self-organization	Concentrative: Emergence
Collective: Collaborative	Individualistic: Competitive
ALTRUIST CULTURE($\uparrow$): Phenotype → Offer, Interactor	SELFISH CAPITAL($\downarrow$): Genotype ← Confirmation, Replicator
HANDSHAKE, INHERITANCE: Synthetic cohabitation of opposites, T (c)	
Definition. An open thermodynamic system of many interdependent parts is complex if it is in synthetic competitive cohabitation with its self induced negative dual in a hierarchical two-phase homeostasy of collective top-down, dissipative, self-organizing, entropy-increasing, phenotypical interactor "culture" and individualistic bottom-up, concentrative, emergent, entropy-decreasing, genotypical replicator "capital", coordinated and mediated by the environment. (d)	

Figure 2*b*: **Universal Darwinism [5].** Universal Darwinism is a generalization of biological Darwinism that applies with "essential and auxiliary explanations specific to each scientific domain", to all open evolving systems sharing the common attribute of variation-inheritance-selection. Hodgson and Knudsen [20] uses this as the defining attribute of universal, generalized Darwinism, distinguished by self-replication. This replicator-interactor dynamics of out-of-equilibrium systems is formalized through the interactor *firm* of cultural selection as vehicles for the *habits* and *routines* — the later as collective analogues of habits of individuals — of replicators of technological innovation. A firm is the entropic expression of exergic routines.

structures, compare Eq. (3). Complex systems therefore realize an induced homeostasis of the entropy and free energy adversaries, with the available enthalpy of maximum Carnot work W_{rev} given. For macroscopic processes, the entropy increase due to E must *eventually* dominate its decrease due to P of increasing exergy, simply because W is administered by the law of increasing entropy.

In justification of the natural existence and applicability of a backward arrow in establishing the dynamics of Nature — as for example in the physical reality of an advanced confirmation wave from an absorber in the future influencing the retarded offer of an emitter in the past — we recall the salient features of a topological argument of [43] that allows a contrapuntal source of "negative entropy" to coexit with the natural entropic signature of the Second Law; for the details the original reference should be consulted. The origin of the unusual "negative entropy" lies in the inducement of an *exclusion topology* [32] in W due to the W $-$ $\mathfrak{W}$ interaction. For any subset $A \subseteq X$, while the normal *A-inclusion topology on* X comprises $\emptyset$ and every superset of A containg A, the abnormal *A-exclusion topology* consists of all subsets of $X - A$ that exclude A. Thus A is open in the inclusion topology and closed in the exclusion, and generally *every open set of one is closed in the other*. For $x \in X$, the *x-inclusion* open neighbourhoods comprises all non-empty supersets of $\{x\}$; the *x-exclusion* neighbourhoods are non-empty open subsets of $\mathcal{P}(X - \{x\})$ *exclusive* of $\{x\}$. The abnormal exclusion topology is in a sense "negative" of the normal inclusion topology: whereas the neighbourhood of a point in the inclusion must always contain the point, the exclusion neighbourhood never contains its defining point. This rather novel property endows the exclusion topology with the remarkable attribute that while any sequence converges to the defining point in its own topology, only the eventually constant $\{v, v, v, \cdots\}$ converges to a $v \neq w$ — all directions with respect to the defining point in this unusual topology are infact equivalent.

For a sequence converging to $w_* \in$ W, there exist according to Eqs. (4*a, b*) an increasing sequence of negelements $(\mathfrak{w}_i)_{i \geq 0} \to \mathfrak{w}_* \in \mathfrak{W}$ in the $\mathfrak{w}_*$-inclusion topology generated by the $\mathfrak{W}$-images of the neighbourhood system of W. Since the only manifestation of neg-sets in the observable world is their influence on W, the $\mathfrak{W}$ sequence converges in $\mathfrak{W}$ if and only if $(w_i)_{i \geq 0} \to w_* \in$ W, which means that the $\mathfrak{w}_*$-inclusion arrow in $\mathfrak{W}$ induces, through its interaction with W, an w_0-exclusion arrow in W opposing the inclusion arrow converging to w_*. The inclusion subspace topology is the natural initial topology on inverse limits

The effect of $(\mathfrak{w}_i)_{i \geq 0} \in \mathfrak{W}$ on W is to regulate the evolution of this forward arrow to an effective state of stasis of dynamical equilibrium. The existence of a negelement $\mathfrak{w} \in \mathfrak{W}$ for every $w \in$ W, by Eqs. (4*a*,

b) requires all forward arrows in W to have a matching forward arrow in 𝔚 that appears backward when viewed in W. It is this opposing complimentary dualistic nature of the apparently backward-𝔚 sequences on W — responsible by (4*b*) for moderating the normal uni-directional evolution in W — that establishes a stasis of dynamical balance between the opposing forces generated in the composite of a compound system and its environment. The conjugation operation of changing a retarded wave Ψ to its complex conjugate advanced state Ψ^* is an example of the inhibitory action of 𝔚 on W. Obviously, such evolutionary processes cease when the opposing influences in W due to itself and its moderator 𝔚 achieve holistic balance, marking a state of dynamic equilibrium. An additional support of these arguments is provided by the inverse and direct limits refered earlier, see Ref. [43] for more.

The following passage from Greaves [15] provides a medical interpretation of the Engine-Pump bidirectionality $\longleftrightarrow$ of Fig. 2*a,b* with reference to cancer (and other chronic diseases). "Intrinsic vulnabarility to cancer must be counterintuitive to anyone who views our bodies as the product of purposeful design or engineering. Darwinian medicine provides the opposite view: the blind process through which we have emerged carries with it inevitable limitations, compromises and trade-offs. The reality is that for accidental or biologically sound adaptive reasons, we have historically programmed falliability. Covert tumours arise constantly, reflecting our intrinsic vulnerability, and each and every one of us harbours mutant clones with malignant potential. Clinical cancer rates would be even worse if it were not for the fact that cancer clone emergence is relatively inefficient evolutionary process, subject to many constraints or bottlenecks. Perhaps only 1% of the covert pre-malignant clone ever acquire the necessary additional or complimentary mutations required for graduation to malignancy." Needless to say, the biologically sound natural entropic adversity of the self-organizing Engine keeps this exergic emergence from P under holistic check.

Define the equilibrium holistic state of homeostatic Engine-Pump adaptability by the equation of state of the participatory universe

$$\alpha(T) := \eta\zeta = \left(\frac{T_h - T}{T_h}\right)\left(\frac{T}{T - T_c}\right) \triangleq \frac{q(T)}{Q_h} = \frac{q(T)}{Q(T)}\left(\frac{T}{T_h}\right), \tag{5a}$$

for

$$q(T) = \left(\frac{1 - \iota(T)}{\iota(T)}\right)\left(\frac{T}{T_h}\right)Q_h, \tag{5b}$$

$Q(T) \triangleq Q_h - W(T) = Q_h - [1 - \iota(T)]W_{\text{rev}} = \left(\frac{T}{T_h}\right)Q_h$, with $Q + q = \left(\frac{T_h - T_c}{T_h}\right)\left(\frac{T}{T - T_c}\right)Q_h = \eta_E\zeta Q_h$, in the form $Pv = f(T)$ where $P \equiv \zeta = 0$ at $T = 0$ and $v \equiv \eta$ as the product of the efficiency η of a reversible engine and the coefficient of performance ζ of a reversible pump, see Fig. 2*a*. Then

$$T_\pm(\alpha) = \frac{1}{2}\left[(1 - \alpha)T_h \pm \sqrt{(1 - \alpha)^2 T_h^2 + 4\alpha T_c T_h}\right] \tag{6a}$$

$$= \begin{cases} ((1 - \alpha)T_h,\, 0) = (0, 0)_{\alpha=1}, & T_c = 0 \\ (T_h,\, -\alpha T_h) = (T_h, T_h)_{\alpha=-1}, & T_c = T_h \end{cases} \tag{6b}$$

for any value of adaptation α. The homeostatic balancing condition

$$\iota(T) = \alpha(T), \tag{7}$$

— where the thermodynamic irreversibility

$$\iota = \frac{T - T_c}{T_h - T_c} \tag{8a}$$

is formally equivalent to the quality of a two-phase mixture[8]

$$x = \frac{v - v_f}{v_g - v_f}, \tag{8b}$$

both T and v being thermodynamic intensive properties with $v_f \leq v \leq v_g$ — defines the most appropriate

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[8]Irreversibility can be interpreted [42] as the *quality* of a two phase liquid-vapour mixture of selfish individualism and altruist collectivism. Holism is a two-phase mixture of "capital" and "culture", interlocked in a feedback confrontation, as are the more than 200 organs in the human body, acting for and on behalf of the whole with the individual organs surviving no longer than the body with the later only their collective phenotypic expression. Collectivism is not an after-thought by-product of individualism: it lies beyond the passivity of the "invisible hand" as an equal player of the win-win game of "life".

equilibrium criterion

$$T_{\pm} = \frac{T_h(T_h + T_c) \pm (T_h - T_c)\sqrt{T_h^2 + 4T_cT_h}}{2(2T_h - T_c)} \tag{9a}$$

$$= \begin{cases} (0.5T_h, 0), & T_c = 0 \\ (T_h, T_h), & T_c = T_h, \end{cases} \tag{9b}$$

that determines the irreversibility of the interaction as the complex holistic state T_+, such that any tendency to revert back to the original condition (small ι: predominance of pump P) implies large E-P adaptability α inviting E-opposition and the homeostasis of Eq. (7). Note that at $T_c = 0$, $T_- = T_c$ while at $T_c = T_h$, $T_+ = T_- = T_c$. Biologically, irreversibility ι corresponds to the selection coefficient s of the fraction of a transformed resource (difference in temperature, specific volume) in terms of the available quantity, where the favoured template phenotype represents the reversible state $\iota = 0$ of no change.
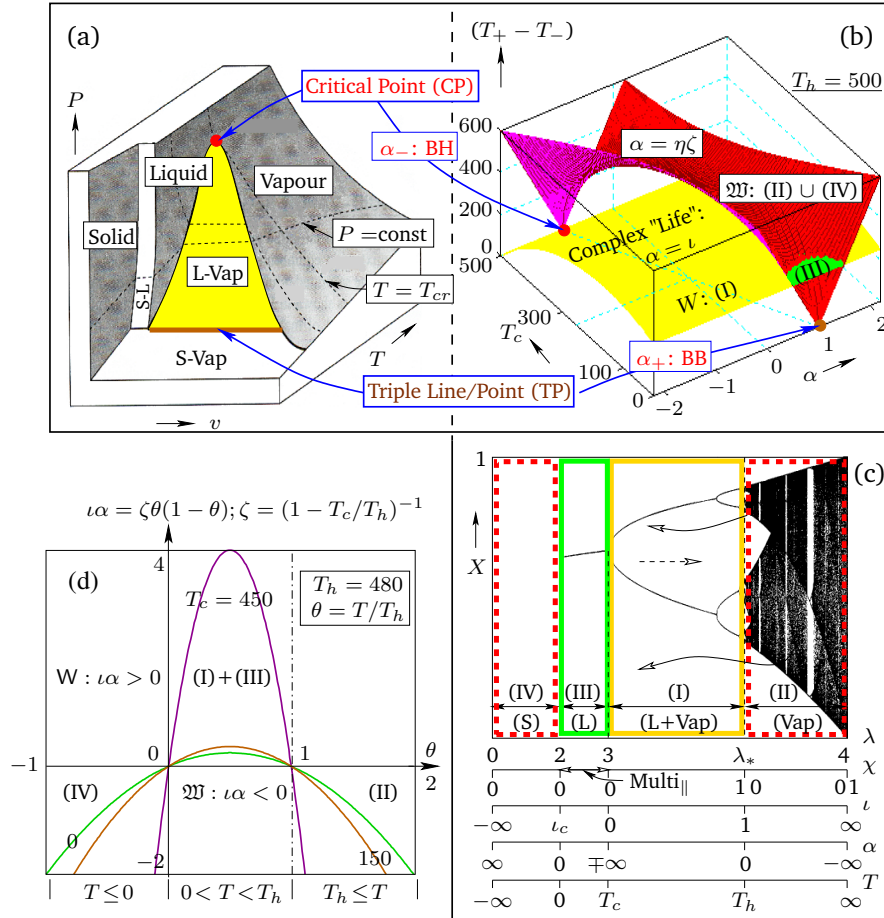

Figure 3: The 2-phase complex $\iota = \alpha$ region, (b) with *critical point* $T_c = T_h$ at $\alpha_- = -1$, yielding to α-dependent $\alpha = \eta\zeta$ at low T_c. The *triple point* $\alpha_+ = 1$, $T_c = 0$ is approachable only through this route. Compared to the normal transition of (a), self-organization in (b) occurs for $\alpha = Pv = $ const. $T_+ - T_- := (T_h - T_c)\sqrt{T_h^2 + 4T_cT_h}/(2T_h - T_c)$ at $\iota = \alpha$ is taken as an indicator of first-order-second-order transition; $\iota\alpha > 0$ in (I)/(III) defines W, $\iota\alpha < 0$ in (II)/(IV) for $\mathfrak{W}$. $\iota_c = -T_c/(T_h - T_c)$. BB: Big Bang, BH: Black Hole.

Of fundamental importance is the fact that the roots Eq. (6a) form continuous curves in the regions $0 \leq T_c \leq T_h$ — meaningful only for $T_h \to +\infty$ — bifurcating as individual holistic components at $\alpha_\pm = \pm 1$: at these values the continuous curves disengage from each other as separate linear entities before "collaborating" once again in generating the profiles $T_\pm$ in the complex region (T_c, T_h). These adaptations of the engine-pump are substantive in the sense that the specific α-values denote physical changes in the global behaviour; they are the critical and triple points in Fig. 3. The two-phase complex surface denoted by $\alpha = \iota$ is to be distinguished from the general Pv region $\alpha = \eta\zeta$. Since the participatory universe satisfies a more involved nonlinear equation (5a) compared to the simple linear relationship of an ideal gas, diagram 3(b) is more involved than the corresponding (a), with the transition at the triple point $\alpha_+ = 1$ displaying very definite distinctive features. While (b) clearly establishes that the triple point cannot be accessed from the

$\iota = \alpha$ surface and requires a detour through the general $\alpha = \eta\zeta$, it also offers a fresh insight on the origin of the insular nature of the absolute zero $T = 0$.

4.2 Two-Phase Mixture of Individualism and Collectivism

Equation (5a) and Fig. 3(b) show that the 2-phase individualistic-collective "liquid-vapour" region $\iota = \alpha$ is distinguished by the imposed constancy of α — and hence of the product Pv — just as P and T separately remain constant in Fig. 3(a). At the critical point $v_f = v_g$ for passage to second order phase transition, $T_c = T_h$ requires $T_+ = T_-$ which according to Eqs. (6b) and (9b) can happen only at $\alpha_- = -1$ corresponding to the $(P_{\mathrm{cr}}, T_{\mathrm{cr}})$ of figure (a). At the other unique adaptability of $\alpha_+ = 1$ at $T_c \to 0$, the system passes into region (IV) from (III) just as (I) passes into (II) as $T_c \to T_h$ at α_-. Observe from Eq. (6a) that

$$(T_c \to 0) \Longleftrightarrow (T_h \to \infty) \tag{10a}$$

allows the self-organizing complex phase-mixture of collaboration and competition to maintain its state T as the condition of homeostatic equilibrium[9] when $(T_+, T_-) = (0, 0)_{\alpha_+=1}$. Simultaneously however, because $T_c < T_h$,

$$(T_c \to T_h) \Longrightarrow (T_h \to \infty) \tag{10b}$$

implies from Eq. (6b) that $(T_+, T_-) = (T_h, T_h)_{\alpha_-=-1}$ is also true. Hence

$$(\alpha_+)_{T_c=0} \sim (\alpha_-)_{T_c=T_h} \tag{10c}$$

generates the equivalence

$$(T_+ - T_-)_{\alpha_+, T_c=0} = (T_+ - T_-)_{\alpha_-, T_c=T_h} \tag{10d}$$

providing an interpretation of the simultaneous validity of Eqs. (10a, b). The limiting consideration (10a) leaves us with two regions: (I) characterized by $\iota\alpha > 0$ of the complex real world W and (IV) of $\iota\alpha < 0$ of the negative world $\mathfrak{W}$. The three phases of matter of solid, liquid and gas of our perception manifests only in W, the negative world not admitting this distinction is a miscible concentrate in all proportions. The reciprocal implications (10a- d) at the big-bang degenerate singularity $\alpha_+ = +1$ at $t = 0$ [43], instantaneously causes the birth of the (W, $\mathfrak{W}$) duality at some *unique admissible* value of α for $0 < T_c < T_h$ and complexity criterion $\iota = \alpha$, breaking the equivalence $\alpha_+ \sim \alpha_-$ of Eq. (10c).

The correspondence between dynamics of the engine-pump system and the logistic map $\lambda x(1 - x)$, with the competitive backward-direct iterates $f^i(x)$ corresponding to the "pump" $\mathfrak{W}$ and the collaborative, forward-inverse iterates $f^{-i}(x)$ to the "engine" W — assured by the exclusion-inclusion topologies and direct-inverse limits — constitutes the basis of our analysis. Note from Fig. 3 that the two-phase complex region $\lambda \in (3, \lambda_*)$, $T \in (T_c, T_h)$, $\iota \in (0, 1)$ is the outward manifestation of the tension between the regions (I), (III) of $\iota\alpha > 0$ on the one hand and (II), (IV) of $\iota\alpha < 0$ on the other: observe that at the environment $T_c = (0, T_h)$ the two worlds merge at $\alpha_\pm = \pm 1$ bifurcating as individual components for $0 < T_c < T_h$. The logistic map — and its possible generalizations — with its rising and falling branches denoted $\female\,(\downarrow)$ and $\male\,(\uparrow)$ constitutes a perfect example of an elementary *nonlinear qubit*, not represented as a (complex) linear combination: non-linear combinations of the branches generate the evolving structures, as do the computational base $(1\ 0)^{\mathrm{T}}$ and $(0\ 1)^{\mathrm{T}}$ for the linear qubit. This qubit can be prepared efficiently by its defining nonlinear, non-invertible, functional representation, made to interact with the environment through discrete non-unitary time evolutionary iterations, with the final (homeostatic) equilibrium "measured" and recorded through its resulting complex structures.

The labeling of the interdependent, interacting, stable points in Fig. 4 is in accordance with the following rule. The interval $[0, 1]$ is divided into two parts at $\frac{1}{2}$ with "0" corresponding to female $\female(\downarrow)$ and "1" to male $\male(\uparrow)$; the rationale in assigning $\female$ to $\mathfrak{W}(\downarrow)$ and $\male$ to W$(\uparrow)$ being that emergence of new structures is anchored in $\female(\downarrow)$ in competitive-collaboration with self-organization in $\male(\uparrow)$, through genetic variation, sexual reshuffling and natural selection for biological life, and consumer culture selection and technological innovation for economic life. At any stage of the iterative hierarchy generated by the unfilled unstable points, the filled stable points are labeled left to right according to the prescription that the female "supply" curve is positively sloped along the x-cost/variation/exergy axis, while male "demand" is of negative slope. The dissipative second-law W $(\uparrow)$-engine runs as long as its demand for evolutionary fuel is met by the induced concentrative anti-second law $\mathfrak{W}(\downarrow)$-pump with necessary supply of variation for selection to work on in a causal-anticausal feedback chain. The "spin" of W is taken to be positive$(\uparrow)$ indicating natural dissipation, that is inhibited by the unnatural increase in free-energy consequent gravitational contraction sourced in negative$(\downarrow)$ $\mathfrak{W}$.

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[9]Does the melting of the arctic icebergs and the recent severe blizards in Europe and USA indicate the veracity of Eq. 10a?

Hence the symbolic representation in a notation of unsegregated homologues denoted by $\{h_1 \parallel h_2\}$, segregated homologues by $h_1 \parallel h_2$, unsegregated sisters by (s_1, s_2), and segregated sisters by s_1, s_2 — a sequence of sisters being separated by a semicolon ; and a square bracket $[\cdots]$ denoting the tensor product blocks in Fig. 1c — becomes

$$N = 1 \quad \text{P}_1 \quad \{0\,(\downarrow) \parallel 1\,(\uparrow)\} \tag{11a}$$

$$N = 2 \quad \text{F}_1 \quad \{00, 01 \parallel 10, 11\} \quad (\text{Fig. } 1a(b)) \tag{11b}$$

$$N = 3 \quad ?? \quad \{000, 001; 010, 011 \parallel 100, 101; 110, 111\} \quad (\text{Fig. } 4(c)) \tag{11c}$$

$$N = 4 \quad \text{F}_2 \quad \{[0000, 0001; 0010, 0011]\,[0100, 0101; 0110, 0111] \parallel$$
$$[1000, 1001; 1010, 1011]\,[1100, 1101; 1110, 1111]\} \quad (\text{Fig. } 1b(c)) \tag{11d}$$

for the self-organized, emergent levels of Fig. 4, the $N = 4$ signature being that of the tensor product of Fig. 1c. The homologous units correspond to respective female-male contributions; thus $\{010 \parallel 110\}$ and $\{0000 \parallel 1000\}$, $\{0101 \parallel 1101\}$ are examples of homologous coupling. However, as pointed out earlier, the $N = 1, 2, 3$-cycles of Fig. 4 represent stable states whereas the dihybrid matrix of Fig. 1c correspond to sex, meiosis, unstable gametes, and progeny zygotes considered in Sec. 4.3. Observe that the homologous components ♀, ♂ lie on either side of the unstable fixed point $B_\lambda = 1 - 1/\lambda$ that yield these components through bifurcation, and that there are no pure nonlinear sisters because of the inevitable mixing of parental properties at every stage of the process; genes replicate in the common background of the other genes and their interactions, not in isolation. "However independent and free genes may be in their journey through generations, they are very much *not* free and independent agents in their control of embrionic development. They collaborate and interact in inextricably complex ways, both with each other, and with their external environment. $\cdots$ The whole set of genes in a body constitutes a kind of genetic climate or background, modifying and influencing the effects of any particular gene" [9].

Observe that the $N = 3$ case of (11c) does not correspond to any progeny level.

As a definite example ($N = 2$), the "entangled" holistic pattern of Fig. 4(b) clearly demostrates that the four components of Eq. (11b) cannot be decoupled into Bell states, being itself nonlinearly "entangled" rather than separated. The various operations historically performed on the respective qubits of the entangled pair to generate dense coding and teleportation ($N = 3$) for example, are not meaningful on the nonlinear holistic entities; in fact it is possibly not significant to ascribe any specific qubit to the individual members of the strings in Eq. (11b). These suggestive differences between linear nonlocality generated by externalities and nonlinear self-evolved complexity are the hallmarks of departures of non-dynamic linear processes as exemplified by Punnett squares and quantum entanglement and complex holism resulting from the homeostasis of "offer" and "confirmation" adversaries of demand and supply.

Figure 4 is a graphic representation of a possible hypothetical correspondence of mitosis — which along with meiosis are among the most definitive attributes of Darwinian evolution — with self-organization and emergence. The unstable haploid gametes[10] of the ova and sperm have only one of each of the 23 chromosomes of the human genome and are, therefore, not stable diploids. Each unstable ○ in (a), (b), and (d) is replaced by two interlinked stable female ♀($\downarrow$) and male ♂($\uparrow$) states: the uncoupled *sister* ● − ○ − ● units of periodic points in (b), for example, can be considered to be replicated bifurcations of the respective periodic ● states of (a). The homologous constituents 0 and 1 remain on their respective sides of the unstable fixed point B_λ: left of B_λ belongs to the female-pump, right to male-engine. A stable diploid cell for some $\lambda < \lambda_2$, destabilizes at $\lambda = \lambda_2$ to generate the homologous pairs of 23 male ♂($\uparrow$) and 23 female ♀($\downarrow$) chromosomes in (a); each chromosome with one allele for every gene and typically a repository of 1000 or more genes, occur in ♀ − ♂ homologous pairs for every non-sex diploid cell in the body represented in the figure by the dash-dot combination of the periodic genotypical states linking the homologous units.

In (b), the environment changes sufficiently for λ_2 to increase to λ_4 destabilizing the stable homologue ♀($\downarrow$)-♂($\uparrow$) resulting in bifurcation to two stable diploid daughters 00 , 10 , 01 , 11 of 46 chromosomes each. It is important to note the difference in the dynamics of mitosis without cross-over, Fig. 4, and meiosis Fig. 5a, with cross-over. In the former the homologous fixed point pairs of $f^{(2n)}(x)$, like the $\{00 \parallel 10\}$ for example, occur for the same curvature profile of the graph of $f^{(2n)}$ unlike in the odd-iterate case $f^{(2n+1)}$ of opposite curvatures, Fig. 5a. This significant difference in the projected dynamics of the mitotic and meiotic cases is interpreted as suggestive of a crossover of one with respect to the other.

Periodic cycles are the "eigenfunctions" of the iterative *generalized nonlinear eigenvalue equation* $f^{(n)}(x) = x$ with iteration number the "eigenvalue" n; unlike the linear case, however, these composite cycles are not linearly superposed but appear as emergent, self-organized, holistic entities. *In this sense complex holism*

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[10]**Gametes** are reproductive sex cells of haploid set of chromosomes. The male reproductive sperm cell fuses with the female reproductive egg or ovum cell to form a diploid fertilized zygote which then develops into a new organism within the female environment. Gametes being haploid are needed in the fertilization of a diploid zygote.
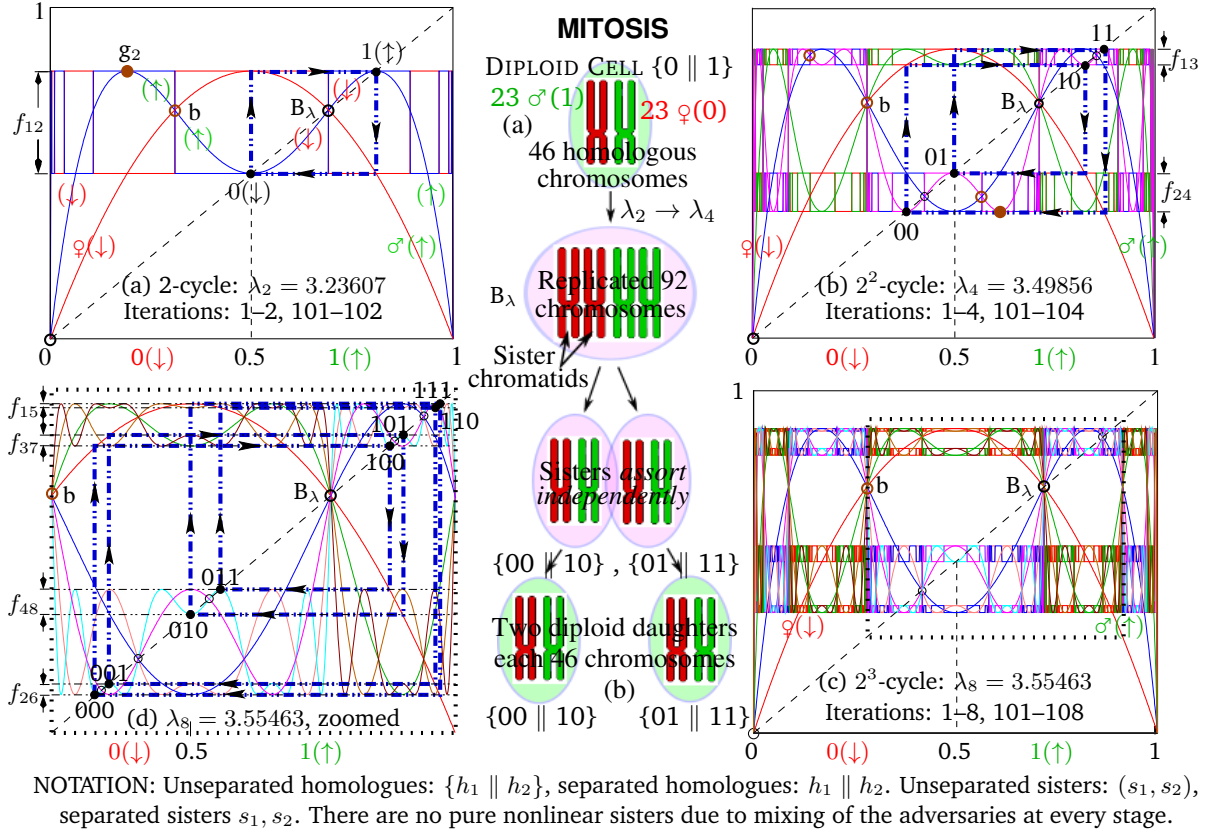
NOTATION: Unseparated homologues: $\{h_1 \parallel h_2\}$, separated homologues: $h_1 \parallel h_2$. Unseparated sisters: (s_1, s_2), separated sisters s_1, s_2. There are no pure nonlinear sisters due to mixing of the adversaries at every stage.

Figure 4: **Mitosis and Complex Evolution.** The effective nonlinearity $0 \leq \chi \leq 1$ of the logistic *nonlinear qubit* $f_\lambda(x) = \lambda x(1-x)$ in the representation $f_\lambda(x) = x^{1-\chi}$ increases with λ, as the system becomes more holistic with an larger number of interacting parts of unstable fixed points shown unfilled, the stable filled points being the interacting, interdependent, components of the evolved pattern. The resulting holistic patterns of one, two $\cdots$ are entangled manifestations of these observables, none of which can be independently manipulated outside of the collaborative whole. Collaboration of the direct iterates $f_\lambda^i(x)$ of individualism and the inverse iterates $f_\lambda^{-i}(x)$ of collectivism leads to homeostasis of the graphically converged multifunctions of dynamic equilibrium. $B_\lambda = (\lambda - 1)/\lambda$ is a *fixed point* of f_λ.

represents a stronger form of "entanglement" than Bell's nonlocality: linear systems cannot be chaotic, hence complex, and therefore holistic. While non-locality is a paradoxical manifestation of linear tensor products, complex holism is a natural expression of the nonlinearity of emergence and self-organization. Nature uses chaos as an intermediate step in attaining states that would otherwise be inaccessible to it. Well-posedness is an inefficient way of expressing a multitude of possibilities as this requires a different input for every output; instead nature chooses to express its myriad manifestations through the multifunctional route [40].

The transactional interpretation embodies — through the "offer" and "confirmation" waves handshaking to complete an explicitly nonlocal "transaction" — the philosophy of the Pump-Engine dualism of chanoxity. In this necessary antagonism between "capital" and "culture" representing bottom-up individualistic competition, entropy decreasing order, and concentrative emergence and top-down collective collaboration, entropy increasing disorder, and dissipative self-organization, complex holism emerges as a dynamical homeostasis of the win-win game in which neither participant wins and neither loses.[11]

4.3 Meiosis and the Negative World

In this Section, we fill in the gaps in the Female-Male rivalrous partnership that constitutes the basis of all holistic expressions of life in Nature. As emphasized earlier, holism of severely stressed, far-from-equilibrium systems, beyond the ambit of reductionism, does not in any way negate its eminently successful analytical tools of mainstream science. These methods — so very successful under "normal" circumstances — are simply inadequate in the "revolutionary" setting of stressed systems where the nonlinearity of mutual feedbacks are essentially indispensable. This bottom-up synthesis does not falsify the top-down analysis of reductionism: it merely suggests that there is a contrapuntal process operating at a higher level, beyond that of reductionism,

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[11]In a **win-win game** all participants profit one way or other; in conflict resolutions, it aims to accommodate all antagonists.
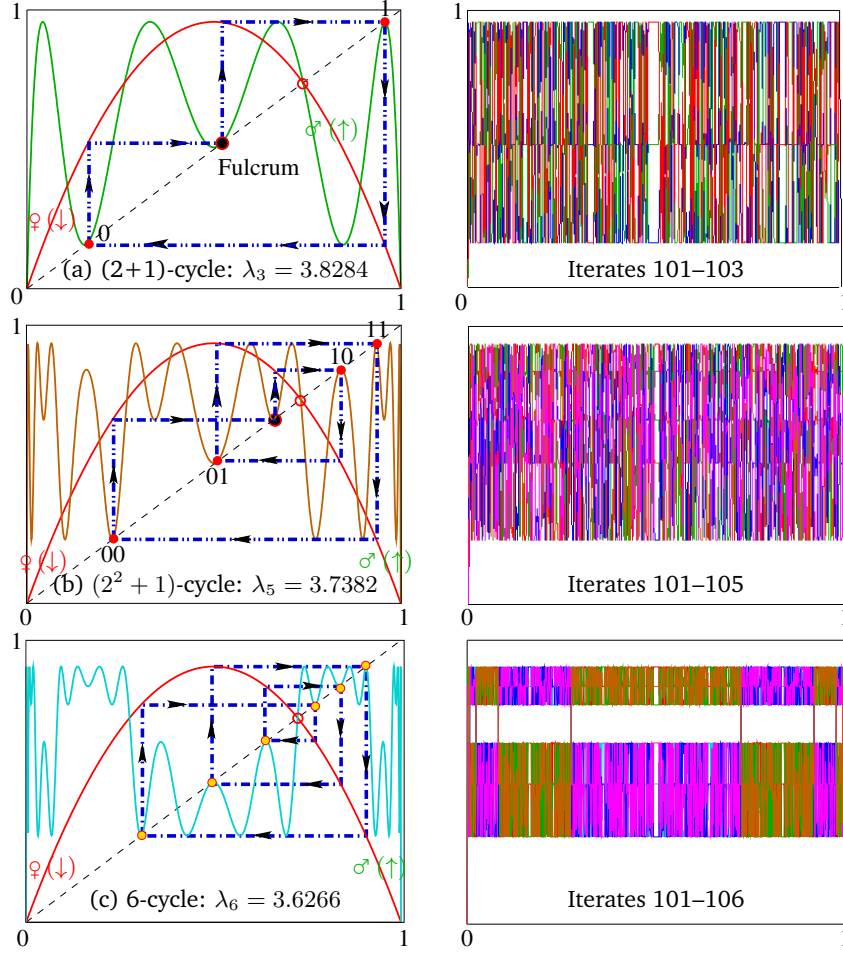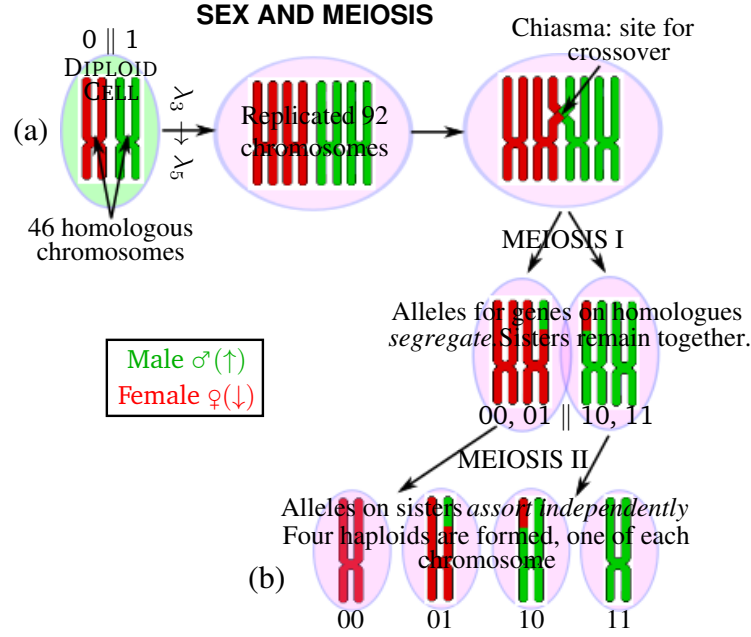
Figure 5*a*: **Meiosis and Complex Evolution (a): Logistics of meiosis.** This diagram, the complement of Fig. 4 for all cycles not of the type 2^N, appears in the chaotic region $\lambda_* < \lambda < \lambda_3 = 1 + \sqrt{8}$, for both odd and even cycles. Odd $(2^N + 1)$ cycles are especially significant as the 3- and 5- cycles correspond to the generation of the haploid gametes as illustrated in Fig. 5*b* below. The "Extended Meiosis" region $\lambda_5 < \lambda < \lambda_*$ is where we believe the embryo and fetus develop leading to birth at λ_*. Left to right 00, 01, 10, 11 are the gametes produced in the 5-cycle of (ii).

as in quantum theory beyond the dispensation of classicalism.

Among the most remarkable features of the appearance of higher forms of life in W involving sexual reproduction is the incredible self-organization of emergent structure appearing simply from a fertilized egg, without any "intelligent design", except for residence in the female uterus: although the zygote can be fertilized outside the body in a "test-tube", it has to be transferred back to the uterus to induce a successful pregnancy. This generation of the order of life assumes special significance in our context because order in the entropic world of W can occur only through gravitational coalescence originating in 𝔚 through the intermediary of an induced pump. The female uterus therefore assumes an important role of biological order in W: it is among the most significant expressions of 𝔚 in W.

Period doubling bifurcations of type 2^N, $N = 1, 2, \cdots$, considered in Fig. 4 were useful in depicting self-organizing, emergent, stable, diploid homologous states of ♀ - ♂ origin. Due to the holistic nature of the dynamics involved, the process is more than simple mitosis, involving the mixing of female-male strategies. Figure 5*a*, the meiotic counterpart of Fig. 4, illustrates the generation of gametes in the self-organizational structure of natural evolution. Note that the 3-, 5-odd cycles of Fig. 5*a*(i), (ii), and the non-2^N even 6-cycle (iii) differ from the 2-, 4-, 8-even cycles of Fig. 4 in having the homologous combinations separated by the additional fulcrum leading to the modification of Eqs. (11*a*, *b*) to represent gametes $0 \parallel 1$ and $00, 01 \parallel 10, 11$. The symbolic representations of Fig. 5*a* constitutes unstable gametes whereas the units of Fig. 4 more correctly represent evolved complex organisms, each in order-disorder homeostasis, at the conclusion of a Meiosis I. Hence it is possible to infer that the nonlinear evolutions of Fig. 4 manifest more than simple mitosis as the replicated sisters always contain crossover components.

The meiotic cycles $f^{(i)} : i \neq 2^N$ in Fig. 5*a*, *b* occur for $\lambda > \lambda_* = 3.5699457$ of the environment parameter in the fully chaotic region that can be characterized by $\chi = 0$ in the power-law representation $f(x) = x^{1-\chi}$

SEX AND MEIOSIS

(iv) (↑) and (↓) chromosomes separate according to Mendel's Laws of Segregation and Independent Assortment. The alleles of a trait segregate into 4 gametes of 23 chromosomes each.

Figure 5b: **Meiosis and Complex Evolution (b).** How the genes exchange according to Mendelian laws of segregation and independent assortment of dyhybrid crossing during meiosis. Let Red denote DOMINANT "Female", Green recessive "Male", replication playing the role of two different traits like the round and yellow seeds in Mendel's experiment. Gamete formation takes place in two stages: MEIOSIS I: *Segregation*. Organism have two alleles of each gene, one from each parent. These alleles, on homologous chromosomes, segregate separately into gametes so that half of the gametes carry one allele and the other half the other allele. MEIOSIS II: *Independent Assortment and cross-over*. Alleles on sister chromatids assort independently, i.e., segregation of alleles of one gene is independent of the segregation of alleles of the other gene. Mendel's Laws are clearly reductionist: in holistic reality independence of segregation and assortment are unlikely to be valid as the existence of a *unique* fulcrum responsible for homologous separation in Fig. 5a suggests.

where χ, the effective nonlinearity of $f(x)$, depends on λ [44]; observe in comparison, that the 2^N cycles in Fig. 4 are all in the complex domain $3 \leq \lambda < \lambda_*$. Hence the time evolution of a natural system can be broken into two components, the stable complex region $3 \leq \lambda < \lambda_*$ complemented by the fully chaotic "quantum" domain $\lambda_* < \lambda \leq \lambda_3$. The chaotic region, in equivalence with $2 < \lambda \leq 3$, is the $\mathfrak{W} - W$ "skin": being the boundary of two homologous adversaries these unstable states that by definition reside in the common neighbourhood of $\mathfrak{W}$ and W connect with the complex region to generate W-organizing, $\mathfrak{W}$-emergent "life". This genotypic supply of individualistic capital "gravity" of $\mathfrak{W}$ is the legacy of the dispersive entropic arrow of the negative world [42] as experienced in W, which induces a demand for its utilization through collaborative culture of the phenotypes. Creation of life in the uterus — and only in the uterus — from the zygote without any "intelligent design" bestows on the female the very special status of an envoy of gravitational order of $\mathfrak{W}$ in the entropic disorder of W. Biological life is supply dominated unlike the economic which is demand driven.

The clear distinction between the 2^N cycles of Fig. 4 and those of Fig. 5a brings out this demarcation forcefully: while the converged multifunction in the former are W-stable horizontal plots for $3 \leq \lambda < \lambda_*$ superimposed on $\mathfrak{W}$-stable verticals, those in the chaotic domain $\lambda > \lambda_*$ are the more subdued W-horizontals embedded in a far more domineering and persistent background of $\mathfrak{W}$-stables, as illustrated by the converged multifunctions for large times. The physics of Fig. 5a portrays birth in dissipation-dictated W, coordinated and controlled by the gravitational authority of $\mathfrak{W}$: as $4 > \lambda \to \lambda_*$, haploid gametes formed in meiosis are fertilized by the injection of sperm to provide the foundations of life, that mature, develop and eventually decay in $\lambda < \lambda_*$.

The value λ_* of λ is of decisive significance. As observed in [41], numerical results suggest that

$$\lim_{N \to \infty} \chi_N \overset{3 \leq \lambda \to \lambda_*}{\longrightarrow} 1$$

at the critical value of $\lambda_* = 3.5699456$. Since $\chi = 0$ gives the simplest linear relation in the effective power law $f(x) = x^{1-\chi}$[41], with

$$\chi = 1 - \frac{\ln\langle f(x)\rangle}{\ln\langle x\rangle}, \qquad 0 \le \chi \le 1, \tag{12a}$$

$$\langle x\rangle \triangleq 2^N \xrightarrow{\lambda=\lambda_*} \infty \tag{12b}$$

$$\langle f(x)\rangle \triangleq 2f_1 + \sum_{j=1}^{N}\sum_{i=1}^{2^{j-1}} f_{i,i+2^{j-1}}, \ N = 1,2,\cdots,$$
$$= \{[(2f_1 + f_{12}) + f_{13} + f_{24}] + f_{15} + f_{26} + f_{37} + f_{48}\} \tag{12c}$$

for $(N=1)$, $[N=2]$, $\{N=3\}$, and

$$\chi_N = 1 - \frac{1}{N\ln 2}\ln\left[2f_1 + \sum_{j=1}^{N}\sum_{i=1}^{2^{j-1}} f_{i,i+2^{j-1}}\right] \tag{13}$$

with

$$\iota = \alpha = \chi, \qquad \lambda \in (3, \lambda_* := 3.5699456) \tag{14}$$

in Regions (I), the measure of complexity [41], the value $\chi = 1$ indicates largest non-linearly emergent complexity so that the logistic interaction is maximally complex at the transition to the fully chaotic region. It is only in this region $3 < \lambda < \lambda_*$ that a global synthesis of stability inspired self-organization and instability driven emergence lead to the appearance of complex structures.

What happens for $\lambda > \lambda_*$ in the fully chaotic region where emergence persists for all times $N \to \infty$ with no self-organization, indicates that on crossing the chaotic edge, the system abruptly transforms to a state of effective linear simplicity. This *jump discontinuity* in χ demarcates order from chaos, linearity from (extreme) nonlinearity, and simplicity from complexity. This emergent but non-organizing region $\lambda > \lambda_*$ competes cooperatively with the complex domain $3 \le \lambda < \lambda_*$ where irreversibility generates self-organizing useful changes in the internal structure of the system in order to attain the levels of complexity needed in the evolution. While the state of eventual evolutionary homeostasis appears only in $3 \le \lambda < \lambda_*$, the relative linear simplicity of $\lambda > \lambda_*$ conceals the resulting self-organizing thrust of the higher periodic windows in this region, with the smallest period 3 appearing at $\lambda = 1 + \sqrt{8} = 3.828427$.

3	$\triangleright$	5	$\triangleright \cdots \triangleright$	$(2n+1)\cdot 2^0$	$\triangleright \cdots$	(II): $\mathfrak{W}: \lambda_* < \lambda \le \lambda_3$. MEIOSIS, Fig. 5$a,b$.
$3\cdot 2$	$\triangleright$	$5\cdot 2$	$\triangleright \cdots \triangleright$	$(2n+1)\cdot 2^1$	$\triangleright \cdots$	$Gonads$: Ovary, Testicle — gametes.
$\vdots$		$\vdots$	$\vdots$	$\vdots$		Gamete compatibility. Cycles ≥ 7 not of
$3\cdot 2^m$	$\triangleright$	$5\cdot 2^m$	$\triangleright \cdots \triangleright$	$(2n+1)\cdot 2^m$	$\triangleright \cdots$	the type 2^n are unstable and do not occur.
						Sex, $\lambda = \lambda_*$. $Fallopian\ tube$: Ovulation,
$\vdots$		$\vdots$	$\vdots$	$\vdots$		Fertilization. Zygote travels up fallopian
						tube and embeds in the wall of uterus.
		($\lambda = \lambda_*$)				Pregnancy.
						(I): W : $3 < \lambda < \lambda_*$. MITOSIS, Fig. 4.
$\cdots \ \triangleright$	2^N	$\triangleright \cdots \triangleright$	2^3	$\triangleright$ 2^2 $\triangleright$	2 $\triangleright$	$Uterus$: Emergence of life.
						$Birth$: Self-organization, Complexity.
				$\triangleright$	1	(III)+(IV): $3 \ge \lambda \to 0$ Decease; Death.
Hence: "Period Three Implies Chaos" [28] in the sense "period three implies all periods".						

Table 1b: Sarkovskii ordering of natural numbers and meosis-mitosis. The period doubling $\lim_{N\to\infty} 2^N$ cycles converge at the chaotic limit $\lambda = \lambda_* = 3.5699456$ from below as do the $\lim_{n,m\to\infty}(2n+1)2^m$ cycles from above. As noted under (III)+(IV), fixed-points are non-dynamic and can only lead to degradation.

By the Sarkovskii ordering of natural numbers, there is embedded in the fully chaotic region a backward arrow that induces connectivity to lower periodic stability eventually terminating in the period doubling sequence in $3 \le \lambda < \lambda_*$. According to this *Sarkovskii Theorem*[12] [46], if $f : \mathbb{R} \to \mathbb{R}$ is a continuous function having a n-periodic point, and if $n \triangleright m$ in ordering of all positive integers of Table 1b then f also has a m-periodic point; the ordering starts with the odd numbers in increasing order, then 2 times the odds, 4 times the odds, $\cdots$, and ends with the powers of two in decreasing order, such that every positive integer appears only once in the list. Sarkovskii's theorem does not entail the stability of all these cycles,

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[12]**Why Three?:** Why does period *three* imply every other period, hence chaos? Why is the physical space *three* dimensional? Why are codon groups of *three* genetic symbols of amino acids needed as the building blocks of proteins? And why are *three* components, ♀, ♂ and the environment, needed for life?

Why is the binary system of two symbols inadequate in cases such as these?

only that they exist, and that there is embedded in the fully chaotic region a backward arrow that induces chaotic tunnelling to lower periodic stability, eventually terminating with the period doubling sequence in $3 \leq \lambda < \lambda_*$. It is this reciprocal connectivity between order and disorder that induces subsequent appearance of life in W. As in the transactional interpretation reflected in Fig. 2a, this homeostasis is a consequence of the collaboration between the forward arrow in time of the retarded *inverse iterates* f^{-i} dictated by the Second Law of increasing entropy and symmetry in W and the backward arrow in time of the advanced *direct iterates* f^i dictated by the reciprocal law of decreasing entropy and symmetry of $\mathfrak{W}$. Should for any reason this natural $\lambda_3 \rightarrow \lambda_* \rightarrow 3 \rightarrow 0$ W-forward arrow be upset, the foundations of homeostasis of life will be disturbed with resulting fatal consequences including cancer if the $\mathfrak{W}$-specific $3 \rightarrow \lambda_*$ gains ascendency in subverting the natural dialectics of $\mathfrak{W} - W$ relationship.

The basic property that distinguishes meiosis from mitosis is the crossover of homologous chromosomes in the former resulting in the production of sperm and egg in the male and female gonads respectively. The life cycle of Table 1a can be split into the four sequential stages.

Stage I. *Meiosis; Formation of gametes:* Formation of the gamete sperm and egg haploids in the male and female gonads. A diploid somatic cell replicates, undergoes cross-over, followed by segregation of the homologous and sister units in sequence to generate the haploid sex cells. The sequence of division is important as mitosis is essentially the segregation of replicated sister units to form two separate diploid cells.

Stage II. *Fusion: Gametes $\mapsto$ Zygotes:* In the fallopian tube the male and female gametes from Stage I and sex fuse as the zygote. This stage requires no addditional resources except the environment of the fallopian and occurs in natural order as an increase in entropy through the generation of zygotic symmetry. The eggs are born to be fertilized which the sperms hunting for; this is the natural outcome of the coexistence of this predator-prey relationship that occurs as a natural consequence of the second law.

Stage III. *Mitosis; Emergence of structures:* Embedding of the high symmetry zygote in the wall of uterus followed by symmetry breaking and emergence of structures in the uterus.

Stage IV. *Birth; Self-organization of emerged structures:* For the first time in the cycle, outside the vehicle of the organism. The emerged structures of Stage III undergo extensive self organization following prolonged mitosis in this stage, finally leading to the complex holism of human existence.

Of the first three stages, gamete $\mapsto$ zygote Stage II is a W-natural consequence of the predator-prey relationship obtaining in the fallopian tube and should therefore be reproducible in an artificailly induced environment, outside the confines of the organismal vehicle. Stages I and III, by contrast, require active collaboration of the free-energy of $\mathfrak{W}$ if the gametes in I and the baby in III are to be produced. These three stages can hence be considered to collectively generalize to an *extended meiosis* — begining with the homologous segregation of Stage I and ending with sister segregation of Stage III — to include the emergent fetal mitosis occuring in the uterus. This generalization, together with Stage IV, completes the self-organized emergence of gametic holism and life in W.

5 Generalized Demand, Supply, Logistic

✪ *The activities of the financial markets are often irrational. Prices go up for no apparent reason and then suddenly the mood changes. What's about the latest spasm that has convulsed bourses in Europe, Asia and North America is that the sell-off is grounded in real and ever-more pressing concerns. Make no mistake, something serious is going on here.*

The first cause for anxiety is the global economy, and in particular the United States. The report released on Thursday, August 18, by the Philadelphia Federal Reserve covers only a small part of the Eastern U.S. but it has a good track record for charting the ups and downs of the world's biggest economy. The Philly Fed's barometer has just plunged deep into recession territory. Two-and-a-half years ago, financial markets rallied strongly on the assumption that the worst of the slump was over. There was relief that Great depression 2 has been avoided. Now the talk is over a double-dip recession. $\cdots$

At least then governments were in a position to ride to the rescue. Today, governments are not seen as the solution but as a part of the problem. What's more, the markets sense that policymakers have run out of bullets to fire. They can't cut official interest rates, they find it hard to justify more quantitative easing when inflation is at current levels and almost every Western government is currently trying to cut its budget deficit.

Put all that together and you get the full package: weak growth, weak banks, weak policy response. That is not a good recipe for shares. Today's Tokyo Nikkei market is at less than 25 percent of its level at the peak of the stock market boom in the late 1980s.   **Larry Elliot** [12]

To establish the comprehensiveness of this positive-negative confrontational feedback in Nature, general characterizations of "demand" and "supply" with universal applicability is needed. From the definitions of

irreversibility ι and adaptibility α, the thermodynamic quantities (see Fig. 2a)

$$Q(T) \triangleq \left(\frac{T}{T_h}\right) Q_h = \left[\iota(T)\left(1 - \frac{T_c}{T_h}\right) + \frac{T_c}{T_h}\right] Q_h$$

$$\iota q(T) \triangleq (1 - \iota(T))Q = (1 - \iota(T)\left[\iota(T)\left(1 - \frac{T_c}{T_h}\right) + \frac{T_c}{T_h}\right] Q_h,$$

for a given environmental input of "fuel" Q_h and adaptivity of the engine and pump α, qualify as the generalized "demand" and "supply" in terms of the reversibility $\rho(T) = 1 - \iota(T)$. Then by definition the non-linear cubic interaction

$$(\iota q)Q = (1 - \iota)\left[\iota\left(1 - \delta\frac{T_c}{T_h}\right) + \delta\frac{T_c}{T_h}\right]^2 Q_h^2, \qquad 0 \le \delta \le 1$$

defines a general supply-demand logistics for demand Q, supply ιq and an environmental scaling parameter δ. While the supply correspondence $S \Leftrightarrow \iota q(T) := \alpha(T)Q_h$ in this positive-negative, auto-feedback loop is fairly obvious, the demand analogy with $Q(T) := (T/T_h)Q_h$ follows because the confrontation of Q and q bestows on the former a collective demand that is met by individualistic supply of q in a bidirectional loop that sustains, and is sustained by each other, in the overall context of the whole. This collective and collaborative consumer demand induces, preserves, and nourishes the individualistic competitive supply q that constitutes the capitalist base of the firm: economic life is demand dominated.
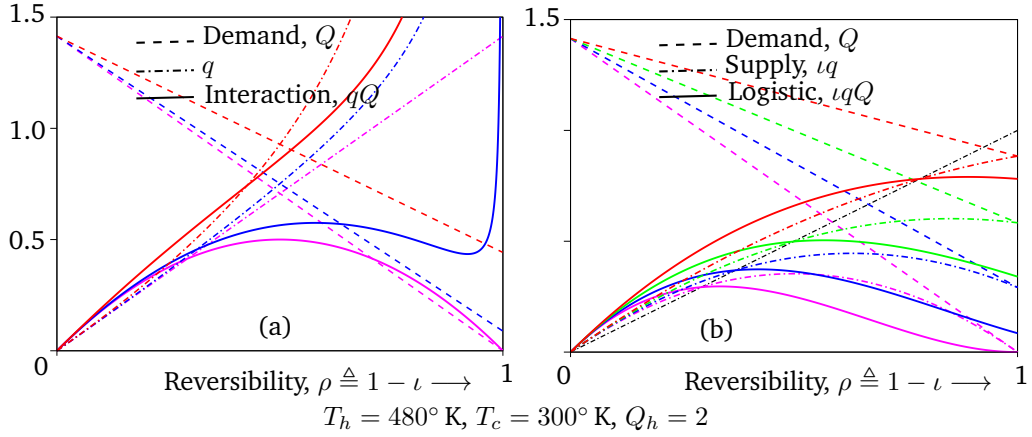

$$T_h = 480° \text{ K}, T_c = 300° \text{ K}, Q_h = 2$$

Figure 6: Homeostasy of $Q = \left[\iota\left(1 - \frac{T_c}{T_h}\right) + \frac{T_c}{T_h}\right] Q_h$ and $\iota q = (1 - \iota Q)$. The cubic interaction $(\iota q)Q$ generates the required $(\uparrow, \downarrow)$ behaviour with respect to the reversibility ρ. Supply is ιq, rather than q, because $q \to \infty$ as $\iota \to 0$, the condition of hot explosive death at maximum variation/concentration, (a). This is unacceptable because as the entropic selection vanishes with ι, the variation free-energy and exergy is expected to collaborate with this adversary and not defect to unlimited strength. Thus $\iota q = Q = \left(\frac{T_c}{T_h}\right) Q_h$ iff $\iota = 0$ at no evolution.

A complex holistic system is distinguished by the fact it tends to maximise its survivality against second law entropic cold death through homeostasy of competitive-collaboration. The plot of this interaction between demand-supply, offer-confirmation, selection-mutation is shown in Fig. 6 for different values of δ.

Modern individualistic, neo-classical economics, is an orthodox static Newtonian equilibrium theory, where supply by the firm equals the demand of the consumer in the mutation-selection balance $sq^2 = \mu_+$ [16] where s the selection coefficient that models thermodynamic irreversibility ι, is a measure of the extent to which natural selection reduces the relative contribution of a given genotype to the next generation, and μ_+ is the forward mutation rate of the allelic change $\mathbf{A} \xrightarrow{\mu_+} \mathbf{a}$, q being the frequency of the recessive allele $\mathbf{a}$. Linear stability is central to this model that has come under severe strain in recent times [2, 3, 13, 18, 45]: mainstream economics is concerned with the economy at a given point in time, not in long-term development.The dynamics of historical change of economics was alien to Adam Smith. The linear mathematics founded in calculus with maximization and contraint-based optimization seeking to maximize utility for the consumer and profit for firms work with reasonable justification as long as its axioms of linearity of people with rational preferences acting independently with full and relevant information make sense. This framework of rationality of economic agents of individuals or company working to maximize own profits, of the "invisible hand" transforming this profit-seeking motive to collective societal benefaction, and of market efficiency of prices faithfully reflecting all known information about assets [2], are relevant under severely

restrictive conditions. In reality, markets are rarely efficient, humans tend to be over-focused in the short-term and blind in the long-term, and errors get amplified, ultimately leading to collective irrationality, panic and crashes.

Several generations of economists "have spent the last century elaborating a system of thought that tries to explain the intricate relationships of economic life with concepts invented to describe the motion of planets. Because the intellectual superstructure of modern Western economics was erected on the foundations of Newtonian physics, it has become untenable" [36]. Free markets are wild markets. Surprisingly, classical economics has no framework through which to understand "wild markets" [2]. These "perfect world" models successfully forecast a few quarters ahead in normal times but fail in the face of revolutionary changes [13], as long as the influences independent of each other, the future is derived from the past with no detectable backward arrow. But the recent collapse, financial and societal, signals a systemic meltdown in which interwined breakdowns have destabilized the system as a whole: "there has been a massive failure of the dominant economic model" [2]. Unable to explain "the awesome complexities of real economic life as experienced by workers and businesspeople, where history matters and change is constant but largely unpredictable, Western economists have barricaded themselves inside their obtuse mathematical models" [36].

The competitive-collaboration of the engine and its self-generated pump is identified as the tension between the consumer with its dispersive collective spending engine (collaborative "culture") in conflict with the individualistic resource generating pump (competitive "capital") in mutual feedback cycles, attaining market homeostasis not through linear optimization and equilibrium of intersecting supply-demand profiles, but through nonlinear feedback loops that generate entangled holistic structures: supply and demand in human society are rarely independent of each other. To take this into account, the interactive feedback between the opposites of engine consumption and pump production can be modelled as a *product* of the supply and demand factors that now, unlike in its static manifestation of neo-classicalism, will evolve in time to generate a condition of dynamic equilibrium.

What is nature's analogy of far-from-equilibrium thermodynamics of open systems? The nonlinear, holistic "mutation-selection balance" of exergy-entropy confrontation depicted in Fig. 2a suggests that economic profit

$$\Pi(Y) = R - C(Y) \qquad (TS) \tag{15a}$$

as the surplus value of reversible Carnot revenue R and total investment free-energy C, with Y the output of the economy, corresponds to irreversibility $\iota(T)$, Fig. 2a. With the specific correspondences

$$
\begin{aligned}
R &= W_{\text{rev}} = \left(1 - \frac{T_c}{T_h}\right) Q_h & \text{(Enthalpy, } U \text{ Fixed)} \\
C(Y) &= W(T) \triangleq (1 - \iota) W_{\text{rev}} = \left(1 - \frac{T}{T_h}\right) Q_h & \text{(Free-Energy, } A) \\
Y &= T,
\end{aligned}
\tag{15b}
$$

Q_h being the total infrastructural resources needed for sustenance of complexity supporting the demand-supply interaction, the $\iota = \alpha$ holism [42] of Fig. 2a is defined by

$$T = \frac{T_h(T_h + T_c) + (T_h - T_c)\sqrt{T_h^2 + 4T_cT_h}}{2(2T_h - T_c)}. \quad \text{(Mutation-Selection balance)} \tag{16a}$$

This nonlinear mutation-selection free-energy-entropy balance requires the very specific $R - C$ relationship

$$C = \frac{3R - R\sqrt{5 - 4R}}{2(1 + R)} \tag{16b}$$

that solves the dynamic holistic problem, the profit being

$$\Pi = \frac{2R^2 - R\left(1 - \sqrt{5 - 4R}\right)}{2(1 + R)}, \tag{16c}$$

with any unutilized profit, unavailable for the benefit of the system when the complex inheritance T of Eq. (16a) is not achieved in (15a) for $\Pi \triangleq TS$, only increasing the entropy of the universe, Fig. 2a, leading to decease and implosive cold-death — holism is Nature's way of reinventing surplus economic energy of profit/benefit as new information, and the economic selection coefficient s (irreversility ι) is Π/R. Adopting the convention that the maximum entropy forward state of dissipation, degradation, and waste comprises

biologically less fit while its opposite of enforced constructivism, usefulness and order defines fitness, the significance of this analysis is that Nature discards the high-entropy "bad" to make way for the low-entropy "good" to achieve a holistic mutation-selection balance for revolutionary, far-from-equilibrium cases beyond Darwinian reductionism, in its dynamical quest of life. Paradoxically either on its own spells doom: tragic heat death of the commons — "Freedom in a commons brings ruin to all" acording to Hardin [17] writing on population increase — or entropic obliteration of cold death. Indeed, "the simplest summary of this analysis $\cdots$ is this: the commons is justifiable only under (near-equilibrium) conditions of low-population density. As the population has increased (to far-from-equilibrium) the commons has had to be abandoned in one aspect after another" [17]; only a judicious intermingling of the opposites can support and sustain Life. Nature is in fact a delicately balanced nonlinear complex of "capital" and "culture" representing the arrows of individualism and collectivism.

In the dynamical two-phase mixture T portrayed in Eqs. (3, 6a, b) and Fig. 2a, the canonical morphisms can be identified with demand Q for the entropy-increasing arrow, and supply ιq for entropy-decreasing feedback in Eq. (3). Their logistic coupling $\iota q Q$ achieves the proper "transactional" interaction via bi-directional "handshake" of supply and demand leading to the homeostasis T of $\mathcal{H}$, that for Eq. (3) translates to $\int \delta(x-a)f(x) = f(a)$, for $\delta \in \Psi^{\times}$ in $\mathfrak{W}$ and $f \in \Psi$ in W. The generalized function $\delta(x)$ is a constant in W for $x \neq 0$ and a constant in $\mathfrak{W}$ at $x = 0$; thus for example the Poisson kernel

$$\delta_{\varepsilon}(x) = \frac{\varepsilon}{\pi(x^2 + \varepsilon^2)} \xrightarrow[\varepsilon \to 0]{\mathbf{G}} 0 \in \begin{cases} \mathsf{W}, & |x| > 0 \\ \mathfrak{W}, & x = 0. \end{cases}$$

converegs graphically to the Dirac delta $\delta(x)$ [40]. Graphical convergence to multifunctions like $\delta(x)$ enlarges the space of functions to correspondences for successful portrayal of chaos and its complex derivatives.

As a classic example of the demand-supply feedback dynamics in $\mathfrak{W} - \mathsf{W}$, consider the Case elementary singular eigenfunction superposition solution

$$\Phi(x, \mu) = a(\nu_0)e^{-x/\nu_0}\phi(\mu, \nu_0) + a(-\nu_0)e^{x/\nu_0}\phi(-\nu_0, \mu) + \int_{-1}^{1} a(\nu)e^{-x/\nu}\phi(\mu, \nu)d\nu; \qquad (17a)$$

of the *linear* monoenergetic neutron transport equation

$$\mu\frac{\partial\Phi(x,\mu)}{\partial x} + \Phi(x,\mu) = \frac{c}{2}\int_{-1}^{1}\Phi(x,\mu')d\mu', \qquad 0 < c < 1, -1 \leq \mu \leq 1 \qquad (17b)$$

for $\Phi(x,\mu) \triangleq e^{-x/\nu}\phi(\nu,\mu)$ and $\int_{-1}^{1}\phi(\nu,\mu)d\mu = 1$, where

$$\left. \begin{aligned} \phi(\mu, \nu_0) &= \frac{c\nu_0}{2}\frac{1}{\nu_0 - \mu} \\ \frac{c\nu_0}{2}\ln\frac{\nu_0 + 1}{\nu_0 - 1} &= 1; \end{aligned} \right\} \quad |\pm\nu_0| > 1$$

$$\left. \begin{aligned} \phi(\mu, \nu) &= \frac{c\nu}{2}\mathcal{P}\frac{1}{\nu - \mu} + \lambda(\nu)\delta(\nu - \mu) \\ \lambda(\nu) &= 1 - \frac{c\nu}{2}\ln\frac{1 + \nu}{1 - \nu}, \end{aligned} \right\} \quad \nu \in [-1, 1]$$

and the conjugate Poisson kernel

$$\mathcal{P}_{\varepsilon}(x) = \frac{x}{x^2 + \varepsilon^2} \xrightarrow[\varepsilon \to 0]{\mathbf{G}} \begin{cases} \frac{1}{x} \in \mathsf{W}, & |x| > 0 \\ 0 \in \mathfrak{W}, & x = 0. \end{cases}$$

converges graphically to the multifunction principal value. Then

$$\Phi_{\varepsilon}(x,\mu) = a(-\nu_0)e^{x/\nu_0}\phi(-\nu_0, \mu) + a(\nu_0)e^{-x/\nu_0}\phi(\mu, \nu_0) + \sum_{i=-N, \neq 0}^{N} a(\nu_i)e^{-x/\nu_i}\phi_{\varepsilon}(\mu, \nu_i) \qquad (18)$$

is the discretized spectral solution [38, 39] of Eq. (17b), where

$$\phi_{\varepsilon}(\nu, \mu) = \frac{c\nu}{2}\frac{\nu - \mu}{(\mu - \nu)^2 + \varepsilon^2} + \lambda_{\varepsilon}(\nu)\frac{\varepsilon}{\pi((\mu - \nu)^2 + \varepsilon^2)} \xrightarrow[\varepsilon \to 0]{\mathbf{G}} \phi(\nu, \mu)$$

$$\lambda_{\varepsilon}(\nu) = \frac{\pi}{\tan^{-1}(1 + \nu)/\varepsilon + \tan^{-1}(1 - \nu)/\varepsilon}\left(1 - \frac{c\nu}{4}\ln\frac{(1 + \nu)^2 + \varepsilon^2}{(1 - \nu)^2 + \varepsilon^2}\right) \xrightarrow[\varepsilon \to 0]{\mathbf{G}} \lambda(\nu)$$

are the regularizations in W of the corresponding singular multifunctions in $\mathfrak{W}$. The excellent numerical results reported in [39] bear testimony to the fruitfulness and reality of $\mathfrak{W} - \mathsf{W}$ collaboration-in-adversity in structuring the complexities of nature.

5.1 Fixed and Periodic Points: The Bottomline

What is the basis of the unflattering observation of Rothschild [36] that the "awesome complexities of real economic life as experienced by workers and business people" have led economists to barricade themselves "inside their obtuse mathematical models"? The reality of the simple Mendel's pea plant experiments — summarized in Sec. 7 below — without the distinguishing features of entanglements, bears testimony of the efficacy of Punett squares and utility matrices — under normal circumstances. In these non-revolutionary situations the simple dynamics governed by the *fixed points* $f(x) = x$ of (not necessarily linear) mappings suffice: the *best response mapping*

$$\beta(s) \triangleq \{\tau : u(\tau, s) = \max_{t \in S} u(t, s)\},$$

where u is the utility/payoff function (see Sec. 6) of any finite two-player symmetric game has a Kakutani fixed point that is a Nash equilibrium for the game, for example. In general the stable fixed points of the replicator-mutator equations are evolutionary stable states. In far-from equilibrium, exclusively nonlinear instances, however, the intricate complexities of the *periodic points*

$$f^{(n)}(x) = x, \qquad n > 1 \tag{19}$$

consisting of the stable fixed points of the nth iterate $f^{(n)}$ of f and their limit cycles determine complex homeostasy in the extended, graphically converged, multifunctional, limit space: understandably invariants of the future — as much as those of the present — determine homeostasy of an evolving dynamical system. The n eigenfunctions of Eq. (19) combine non-linearly through equivalence classes as in Figs. 4 and 5a to generate the homeostasy of self-organized altruism from the emergent selfish individualism of the eigenvectors. This is how altruist collectivism reciprocates selfish individualism that in turn is sustained by the generosity sourced in the inevitable entropic dissipation — meaningful only under the exergic concentration of $\mathfrak{W}$-individualism — in W. Entropic altruism is natural in W; exergic individualism emerges only to sustain it.

An example of the revolutionary mutation-selection balance is illustrated in Fig. 2a. The equilibrium condition T representing the graphically converged 2^N chain-dashed limit cycles of Figs. 4 and 5a is to be compared with the well-known equilibrium frequency under the fixed-point condition $\Delta q \equiv q_{t+1} - q_t = 0$ [30], with q a sum of the conflicting contributions of decreasing entropic-selection and increasing exergic-mutation. Then for genotypes **AA**, **Aa** and **aa**, with [16]

$$\Delta q_{\text{NS}} = -\frac{s(1-q)q^2}{1-sq^2} \tag{20a}$$
$$\Delta q_{\text{Mut}} = \mu_+(1-q),$$

the fixed point requirement $\Delta(q_{\text{NS}} + q_{\text{Mut}}) = 0$ of

$$q_{\text{eq}} = \sqrt{\frac{\mu_+}{\mu_+ s + s}} \tag{20b}$$

reduces to the classical result $\sqrt{\mu_+/s}$ — with $s = 0$ in the denominator of (20a) for the mean relative fitness $\overline{w} = w_{\mathbf{AA}}p^2 + w_{\mathbf{Aa}}2pq + w_{\mathbf{aa}}q^2 \approx 1$, Fig. 2$a$ — for $\mathbf{A} \underset{s}{\overset{\mu_+}{\rightleftarrows}} \mathbf{a}$. In comparison the periodic-cycle, complex-holistic, chain-dashed attractors of Figs. 4 and 5a asymptotically lead to the global, multifunctional phenotypes over many (essentially infinite) generations as shown in the respective figures.

Clearly the intricacies of nonlinear periodicity and chaos can lead to startlingly new possibilities beyond the reach of fixed-point reductionism.

6 Punnett Square and Economic Payoff: The Mixed Nash Equilibrium

Game Theory — the formal study of conflict and collaboration — is designed to address situations in which the outcome of a person's decision depends not just on how he individually operates but also on the collective behaviour of the other interdependent members he interacts with: this in essence constitutes *competitive-collaboration* of unity-in-diversity, perforce linear in the game theoretic setting. The basic principle of biology and their economic correspondences that mutations are more likely to succeed when they improve the reproducibility of the concerned organism holds only as far as it goes — genotype fitness is not an individualistic attribute, it depends collectively on all other (non-mutant) parts, with linear (quantum) non-locality and non-linear (complex) holism being the inevitable consequences. In the linear setting therefore, equilibrium

concepts like Nash equilibrium, Pareto optimality, tensor products should be relevant in the study of Punnett squares — a shorthand way of determining the probability of having a certain type of offspring given the parents' genotypes — culminating in a global appreciation of the homeostatic holism of which these are but linear manifestations.

In this Section our aim is a formalization of the reductionist techniques of linear non-locality that share common features with the checkerboard methods of Punnett square, a summary of every possible combination of one maternal allele with one paternal allele used by biologists to determine the probability of an offspring having a particular genotype, and the game-theoretic economic payoff (utility) matrix of a (normal-form) game $\mathscr{G} = \langle P, \mathbf{S}, \mathbf{u} \rangle$ of a finite set $N = \{n\}_{n=1}^{N}$ of N diploid *players* P, $\mathbf{S} = \{S_n\}_{n=1}^{N}$ a set of *pure strategies* $S_n = \{1, 2, \cdots, k_n\}$ available to player n, $\mathbf{s} = \{s_n \in S_n\}_{n=1}^{N}$ a pure strategy profile of the players, and $\mathbf{u} = \{u_n \colon \prod_{m=1}^{N} S_m \to \mathbb{R}\}_{n=1}^{N}$ the real-valued economic *utility (payoff) functions* for the players.

Our starting point is the realization, following Figs. 1a and 1b, that the Punnett square can also be expressed in the language of economic utility/payoff matrices, in the global backdrop of non-locality motivated by tensor products of Fig. 1b under the formal correspondences

Biology	Game Theory
Female ♀(↓)	Player 1
Male ♂(↑)	Player 2
Allele/ Gamete Spin (↓)	Strategy 1
Spin (↑)	Strategy 2
Genotype fitness	Utility/Payoff

The utility matrix corresponding to Fig. 1a (b) then becomes

		♂ Allele/Gamete	
Player ♂: Engine		Strategy/Frequency	
Player ♀: Pump		0 (↓)	1 (↑)
♀ Allele Frequency		q	$(1-q)$
0 (↓)	p	↓,↓	↓,↑
1 (↑)	$(1-p)$	↑,↓	↑,↑
		Offspring genotypes	

With all payoffs positive because of emergence and self-organization, it is clear that in addition to any pure strategy Nash equilibria, there is a mixed strategy equilibrium

$$(p, q) = \left(\frac{u_{22}^{(2)} - u_{21}^{(2)}}{(u_{11}^{(2)} + u_{22}^{(2)}) - (u_{12}^{(2)} + u_{21}^{(2)})}, \frac{u_{22}^{(1)} - u_{12}^{(1)}}{(u_{11}^{(1)} + u_{22}^{(1)}) - (u_{12}^{(1)} + u_{21}^{(1)})} \right) \tag{21a}$$

for a genotype utility matrix $\mathbf{U} = \{(u_{mn}^{(1)}, u_{mn}^{(2)})\}_{m,n=1}^{2}$ where the allele frequency $p \in (0, 1)$ is total number of (↓) alleles in the population as a fraction of $2N$ is the probability of Player 1 choosing strategy (↓) (and $1 - p$ of choosing (↑)) and $q \in (0, 1)$, $1 - q$, are the probabilities of Player 2 doing the same.

For symmetric games — like Prisoner's Dilemma and Hawk-Dove, when agents do not have distinct roles and the payoffs are independent of their identities — $(u_{mm}^{(1)} = u_{mm}^{(2)})_{m=1,2}$, $(u_{mn}^{(1),(2)} = u_{nm}^{(2),(1)})_{m \neq n}$, the equilibrium allelic/gamete strategy reduces to $q = p$ with

$$p = \frac{u_{22}^{(1)} - u_{12}^{(1)}}{(u_{11}^{(1)} + u_{22}^{(1)}) - (u_{12}^{(1)} + u_{21}^{(1)})}, \tag{21b}$$

for respective genotype payoffs $u_{11}^{(1)} q + u_{12}^{(1)}(1 - q)$ of Player 1 (Pump), and $u_{11}^{(2)} p + u_{21}^{(2)}(1 - p)$ for Player 2 (Engine). In an anti-coordination games without uncorrelated asymmetry defined by $u_{11}^{(1)} = u_{11}^{(2)} = \mathcal{C}$, $u_{22}^{(1)} = u_{22}^{(2)} = \mathcal{T}$, $u_{12}^{(1)} = u_{21}^{(2)} = \mathcal{W}$, $u_{12}^{(2)} = u_{21}^{(1)} = \mathcal{L}$, the mixed strategy pair

$$(p, q) = \left(\frac{\mathcal{W} - \mathcal{T}}{(\mathcal{W} - \mathcal{T}) + (\mathcal{L} - \mathcal{C})}, \frac{\mathcal{W} - \mathcal{T}}{(\mathcal{W} - \mathcal{T}) + (\mathcal{L} - \mathcal{C})} \right) \tag{21c}$$

is a Nash equilibrium, provided $p = q \in (0, 1)$, with an expected genotype fitness utility

$$\frac{\mathcal{W}\mathcal{L} - \mathcal{T}\mathcal{C}}{(\mathcal{W} - \mathcal{T}) + (\mathcal{L} - \mathcal{C})}.$$

Consider the Pump-Engine system as a two-player game between players ♀ Capital and ♂ Culture each with allele strategies (↑) derived from male parental Engine Culture and (↓) from female Pump Capital, Fig. 1a (b). In this hybrid, Capital-Culture discoordination $\mathfrak{W} - \mathrm{W}$ game [13] with the players conscious of their identities and strategies, the non-symmetric Pump-Engine utility of (a) compared to the symmetric Hawk-Dove (b), the indicated payoffs are interpreted as follows.

(a) CULTURE ♂	♂			(b) DOVE ♂	♂			(c) PRISONER	Player ♂	
CAPITAL ♀	(↓)	(↑)		HAWK ♀	H(↓)	D(↑)		DILEMMA	D(↓)	C(↑)
♀ (↓)	$\mathcal{T},\mathcal{L}$	$\mathcal{C},\mathcal{W}$		♀ H(↓)	$\mathcal{C},\mathcal{C}$	$\mathcal{W},\mathcal{L}$		Player ♀ D(↓)	$\mathcal{L},\mathcal{L}$	$\mathcal{W},\mathcal{C}$
(↑)	$\mathcal{C},\mathcal{W}$	$\mathcal{L},\mathcal{T}$		D(↑)	$\mathcal{L},\mathcal{W}$	$\mathcal{T},\mathcal{T}$		C(↑)	$\mathcal{C},\mathcal{W}$	$\mathcal{T},\mathcal{T}$
$\mathcal{W}$ (win) > $\mathcal{T}$ (tie) > $\mathcal{L}$ (lose) > $\mathcal{C}$ (crash)										

1. ↓↓: ♀(↓) dominates ♂(↓). This implied inhibition of entropic dissipation of the items following, is the source of complexity, holism, and life.

2. ↓↑: ♂(↑) dominates ♀(↓).

3. ↑↑: ♂(↑) dominates ♀(↑).

4. ↑↓: ♂(↓) dominates ♀(↑).

The male authority of 2, 3, 4 reflects the eventual entropic real world dissipation in W over exergy moderation 1 from $\mathcal{W}$. Without 1 however, there would be entropic cold death exclusively: no life, only the structureless frozen global symmetry of the second law.

It is significant that the payoffs for P-E is distinguished by the absence of Pump resource $\mathcal{W}$ in the row entries and the absence of Engine resource $\mathcal{C}$ in the column entry. This curious feature of the P-E realization as observed earlier in [42], represents the essence of competitively collaborating unity-in-diversity: the dispersion of E is proportional to the domain $T - T_c$ of P, and the concentration of P depends on $T_h - T$ of E. Thus an increase in ι can occur only at the expense of P which opposes this tendency; reciprocally a decrease in ι is resisted by E. The induced pump P prevents the entire internal resource $T_h - T_c$ from dispersion at $\iota = 1$ by defining for some $\iota < 1$ a homeostatic temperature $T_c < T < T_h$, with E and P interacting with each other in the spirit of competitive-collaboration at the induced inheritance T. This inverse dependency of the two-phase Pump-Engine system characterizes its collaborative-competitiveness and directly contributes to the emergence of self-organization.

Our variant of the Hawk-Dove game based on the reality that the Dove, true to the Engine it models, is a scavenger that cannot be sustained without supply of resource from the Hawk Pump — which in turn with its explosive concentration of $\mathfrak{W}$ free-energy that has no place in the entropic world of W except in association with agents that can make use of it — is not viable in isolation of the Dove, has no pure Nash Equilibrium. The equilibrium

$$(p,q) = \left(\frac{\mathcal{W} - \mathcal{T}}{2\mathcal{W} - (\mathcal{T} + \mathcal{L})}, \frac{\mathcal{L} - \mathcal{C}}{\mathcal{T} + \mathcal{L} - 2\mathcal{C}} \right)$$

of probabilities from Eq. (21c) is a mixed Nash equilibrium for the Capital-Culture game with payoffs

$$\left(\frac{\mathcal{T}\mathcal{L} - \mathcal{C}^2}{\mathcal{T} + \mathcal{L} - 2\mathcal{C}}, \frac{\mathcal{W}^2 - \mathcal{T}\mathcal{L}}{2\mathcal{W} - (\mathcal{T} + \mathcal{L})} \right).$$

for ♀ Female and ♂ Male respectively; note again that while the pump p is independent of $\mathcal{C}$ and the engine q of $\mathcal{W}$, the *utility* of the Female bears the expected inverse independence of $\mathcal{W}$ and the Male Engine of $\mathcal{C}$.

Generally for an even ordered $I \times I$ utility matrix with probabilities $\{p_i : \sum p_i = 1\}$ and $\{q_j : \sum q_i = 1\}$ for the allele strategy/gamete frequency of Female and Male respectively, the homozygous sum of the diagonal products $\sum p_i q_i$ represents the irreversibility ι responsible for ensuring entropic selection of fitness, while the heterozygous $\sum_{i \neq j} p_i q_j$ of the off-diagonal terms represents variation $(1 - \iota)$ of dynamic evolution. This suggests a correspondence of thermodynamic irreversibility with the diagonal terms of the utility matrix, and of reversibility with the off-diagonal terms. Quantum decoherence of the heterozygous component is a mechanism by which open quantum systems of superpositions interact with their environment to generate

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[13]In *anti-coordination games*, $u_{11}^{(1)} < u_{21}^{(1)}$, $u_{22}^{(1)} < u_{12}^{(1)}$, $u_{11}^{(2)} < u_{12}^{(2)}$, $u_{22}^{(2)} < u_{21}^{(2)}$, competing with different strategies for the rivalrous and non-excludable shared resource is mutually beneficial for the players: sharing comes at a cost of negative externality. In *coordination games*, $u_{11}^{(1)} > u_{21}^{(1)}$, $u_{22}^{(1)} > u_{12}^{(1)}$, $u_{11}^{(2)} > u_{12}^{(2)}$, $u_{22}^{(2)} > u_{21}^{(2)}$, collaborating the resource is beneficial for all; the resource is non-rivalrous, sharing creating positive externalities. A *discoordination* game $u_{11}^{(1)} > u_{21}^{(1)}$, $u_{22}^{(1)} > u_{12}^{(1)}$, $u_{11}^{(2)} < u_{12}^{(2)}$, $u_{22}^{(2)} < u_{21}^{(2)}$ combines both for simultaneous competition and collaboration at the linear reductionist level.

spontaneous suppression of interference and appearance of the definiteness of classical objectivity. This irreversible decay of the off-diagonal terms is the basis of decoherence that effectively bypasses "collapse" of the state to one of its eigenstates on performing a measurement. Non-local entanglement and interference, are more pronounced and pervasive in nonlinear complexity than in linear, isolated and closed, quantum systems. Complex homeostasy of holism that cannot be represented by the classical objectivity of wave-function collapse or of decoherence is a reminder of the limitations of linear characterization of severely nonlinear, far-from-equilibrium, systems. In this sense the mixed Nash equilibria — which respects both (linear) interaction and interference and is more non-local than either decoherence or wave-function collapse of quantum systems can admit — is a more faithful portrayal of the objective reality of complexity and holism.

Heterozygosity of an organism, as considered in ChaNoXity, is a continuous parameter determined by the homeostasy of T which arises from the mulifunctional graphical limit of $(\uparrow\uparrow) \oplus (\uparrow\downarrow) \oplus (\downarrow\uparrow) \oplus (\downarrow\downarrow)$.

6.1   The Central Dogma: Limitations of Linear Reductionism

DNA contains the codes for manufacturing various proteins. According to the central dogma of molecular biology, the one-way flow of information DNA $\rightarrow$ RNA $\rightarrow$ Protein is the basis of all life on Earth: "once information has passed into protein, it cannot get out again" [7], back to the nucleic acid. The 3 major classes of biopolymers — nucleic acids DNA, RNA and protein — allow 9 possible reductionist transfer of information as shown in Table 2: normal *general transfers* ☺ that can occur in all cells, restricted *special transfers* ☹ do not occur in most cells but may occur in special circumstances as in virus-infected cells and in the laboratory, and forbidden *unknown transfers* ✝ [7].

	DNA	RNA	Protein
DNA	☺	☺	☹
RNA	☹	☹	☺
Protein	✝	✝	✝

Table 2: **The Central Dogma** of molecular biology states that mRNA is transcribed faithfully from DNA and is translated faithfully into protein: DNA $\overset{\text{replication}}{\longrightarrow}$ DNA $\overset{\text{transcription}}{\longrightarrow}$ mRNA $\overset{\text{translation}}{\longrightarrow}$ Protein, as deterministic copy-paste, one-to-one, faithful transfers. The zygote self-replicates into two cells that divides into two and the process of mitosis continues. A gene is a functional unit on a chromosome which directs the synthesis of a particular protein. Humans have 23 pairs of chromosomes, each with two non-identical copies one derived from each parent.

The above reductionist approach suffers the same individualistic limitations considered earlier: the entropy increasing free-energy utilization of genetic information through bidirectional feedback leading to the forward DNA $\rightarrow$ RNA $\rightarrow$ Protein process does not forbid, rather it actually seeks, the antagosistic dissipation-concentration collaboration inside the female body. It is quite remarkable that this replication-transcription-translation mechanism requires the $\mathfrak{W}$-environment of the uterus as the source and sustenance of locally induced gravitational concentration of genetic information stored in the DNA. According to this view all the components of Table 2 participate collectively and competitively in enabling the forward generation of proteins, the other arrows being hidden from direct observation under normal circumstances. Without them however, the information content of the DNA might not have been there in the first place, the observed forward arrow being the consequence of mutual antagonism of entropy and exergy. This bidirectional information flow in complex biological systems — rather than the uni-directionality of classical dogma — appear to support the recent finding of widespread differences between DNA sequences and their corresponding RNA transcripts in human cells [27] demonstrating that these differences result in proteins that do not precisely match the genes that encode them, and that mRNA and proteins — not simply the DNA — might hold the key to understanding the genetic basis of molecular biology. The "mad cow disease" (BSE) for example, have been recorded to be transmitted even after the infectious media was treated by means that normally destroy genetic material, DNA and RNA. When the medium was treated by agents that only destroy proteins and leave nucleic acids intact, the infection was however blocked. This immediately indicates that BSE is actually transmitted by proteins.

Molecular geneticists studying the genetic material have over the last few decades been turning up evidence that increasingly contradicts the Central Dogma. There is an immense amount of necessary cross talk between genes and the environment, that not only changes the function of the genes but also the structure of the genes and genomes. Thus Shapiro [45] believes that the following lessons from current molecular discoveries "are likely to lead us to a significant reformulation of our basic assumptions about the organization

and role of the genome in phenotypic expressions, heridity, and evolution".

- There is no unidirectional flow of information from one class of biological molecule to another. Many types of molecules participate in information transfer. In particular, genomic functions are inherently interactive because isolated DNA is virtually inert and probably never exists in that state in a cellular context. DNA cannot replicate or segregate to daughter cells by itself.

- Classical atomistic-reductionist concepts are no longer tenable. Each process involves multiple molecular components and one region of the genome may be important for more than one process. Heredity thus has to reflect the inherently systemic and distributed nature of genome organization.

- The post-central dogma discoveries relate to the importance of multivalent and combinatorial techniques. The mobility and interaction of different submolecular domains are increasingly apparent. It is of great biological significance that multivalent operations provide the potential for feedback, regulation, and robustness that simple mechanical devices lack.

- Genomic change arises from natural genetic engineering, not from accidents. Realization that DNA change is a biochemical process opens up new ways of thinking about the role of natural genetic engineering in normal life cycles and the potential for nonrandom processes in evolution.

- Informatic-entropic rather than mechanistic processes control cell-functions.

- Feedback signals play a central role in cell operations. The use of signals is critical for basic functions like homeostatic regulation, adaption to changing conditions, cellular differentiation, and multicellular morphogenesis. Unpredictable signals in biological processes generates an inescapable indeterminacy that contradicts the central dogma and other reductionist statements of genetic determinism.

The general correspondence of the above with the foundations of chanoxity are all too evident to require further elaboration, all of which goes against the basic tenets of central dogma of linear, mechanistic control. Instead, "layers upon layers of chaotic complexity are coordinated, it seems, by mutual agreement, in an incredibly elaborate, exquisite dance of life that dances itself freely and spontaneously into being" [18]; [10, 22, 24, 25, 35]. To reflect this new realism, our use of the terms "variation" includes sexual genetic recombination, gene flow, HGT, and "selection" admits random genetic drift available on demand in extreme circumstances: while an organism's phenotype is obviously determined by its genotype and the environment, the new dialectics requires higher forms of homeostasis to be an expression of a win-win game between the two that itself generates and sustains each other.

6.2 The Entropy-Exergy Antagonism — Protein Folding

These considerations should have some important bearing in the understanding of protein folding in hydrophobic media. The hydrophobic effect is fundamentally based on the tendency of polar water molecules to exclude non-polar molecules leading to the segregation of water and non-polar substances and apparent repulsion between water and hydrocarbons. The hydrophobic effect is an important force providing the main impetus for protein folding, formation of the lipid bilayer, insertion of membrane proteins to the nonpolar lipid environment and protein small molecule interactions.

Depending on the polarity of the side chain, amino acids vary in their hydrophilic or hydrophobic character. These properties are important in protein structure and protein-protein interactions. The importance of the physical properties of the side chains arises from its influence on amino acid residue interactions with other structures, both within and between proteins. The distribution of hydrophilic and hydrophobic amino acids determines the tertiary structure of the protein, and their physical location on the outside of the proteins influences their quaternary structure. Hydrophilic and hydrophobic interactions of the proteins need not rely only on the side chains of amino acids. By various post-translational modifications other chains can be attached to the proteins, forming hydrophobic lipoproteins or hydrophilic glycoproteins.

Protein folding, Fig. 7, is the physical process by which a polypeptide folds into its characteristic and functional three-dimensional structure from a random coil. Each protein exists as an unfolded polypeptide random coil when translated from a sequence of mRNA to a linear chain of amino acids, the amino acids interacting with each other to produce the well-defined three-dimensional folded protein. Folded proteins have a hydrophobic core in which side chain packing stabilizes the folded state, and the hydrophilic charged or polar side chains occupy the solvent-exposed surface where they interact with surrounding water. Minimizing the number of hydrophobic side-chains exposed to water is an important driving force behind the folding process. For hydrophobic collapse the free-energy increases with corresponding decrease in entropy in the interior, in the hydrophilic surface exterior the opposite happens preventing thereby total collapse of

the interior. The folded protein represents homeostasy of the entropy and free-energy/exergy adversaries. In this new form of dynamism, individuals retain their identity in contributing to the collective that sustains them as much as their nurture and support keeps the commune from disintegrating. While this may not be the best option for either, without the collective pluralism, neither would be better off. Recall that a misfolded protein can be a serious liability rather than an asset; the correct three-dimensional structure is essential. Failure to fold into the intended shape usually produces inactive proteins with different undesirable properties including toxic prions. Several neuro-degenerative diseases can result from incorrect misfoldings, and many allergies may be caused if the immune system fails to produce the required antibodies.

A *micelle* is an aggregate of surfactant molecules dispersed in a liquid colloid. A typical micelle in aqueous solution forms an aggregate with the hydrophilic head regions in contact with surrounding solvent, separating the hydrophobic single tail regions in the micelle centre. Inverse micelles have the headgroups at the centre with the tails extending out. Micelles are approximately spherical in shape This process of micellization is part of the phase behavior of many lipids according to their polymorphism. Micelles form spontaneously because of a balance between hydrophilic entropy and hydrophobic free-energy. In water, the hydrophobic effect is the driving force for micelle formation, despite the fact that assembling surfactant molecules together reduces their entropy. At very low concentrations of the lipid, only monomers are present in true solution. As the concentration of the lipid is increased, a point is reached at which the unfavorable entropy considerations, derived from the hydrophobic end of the molecule, become dominant. At this point, the lipid hydrocarbon chains of a portion of the lipids must be sequestered away from the water. Therefore, the lipid starts to form micelles, thereby con-
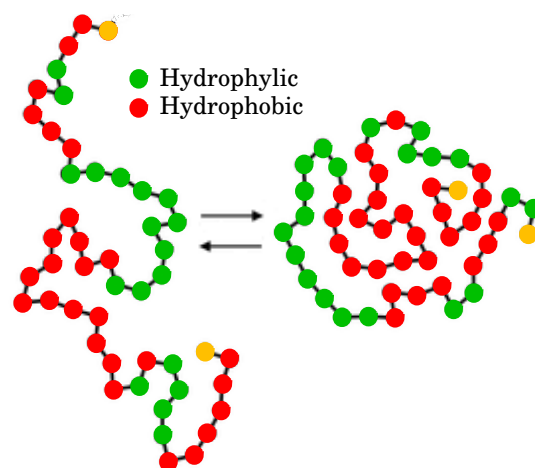

Figure 7: Hydrophilic entropic dispersion cohabitating with hydrophobic free-energy concentration is the guiding principle of protein folding. In this entropy $\rightleftarrows$ exergy confrontation, neither of the adversaries win, neither lose: no one dominates and none is recessive. The genotype$\rightarrow$phenotype map is typically non-injectively non-invertible — a necessary condition for emergence and self-organization.

stituting a natural mechanism of forming nanoparticles. Targeted drug delivery to tumors, for example, piggybacking such natural vehicle is an attractive possibility; however given the holistic nature of the human complex system, it is not clear how much of this "targeting" can remain outside the mutual influence of non-targeted organisms. This opens up the domain of Darwinian or evolutionary medicine, the applications of evolutionary theory to health and disease that provides a complementary approach to the mechanistic explanations that dominate medical science, particularly medical education [34].

7 Conclusion: Irreducible Complexity Without Intelligent Design

✪ *A scientific revolution happens when the paradigm (of normal science) breaks down. In normal periods you need only people who are good at working with the technical tools — the master craftspeople. During revolutionary periods you need seers, who can peer ahead into the darkness.* $\cdots$ *We are in a revolutionary period but are using the inadequate tools of normal science. We are horribly stuck and need real seers, badly.* $\cdots$ *Do you want a revolution in science? Let in a few revolutionaries. The payoff could be discovering how the universe works.* **Lee Smolin**, The Trouble with Physics: The Rise of String Theory, the Fall of a Science, and What comes Next, Houghton Mifflin Company, New York, (2006).

The new world-view of complex holism calls for a renovation of the way science is done: "We are", undoubtedly, "in a revolutionary period but are using the inadequate tools of normal science". The new science has a distinctive mathematics of nonlinearity, multiplicity, non-smoothness and equivalence classes leading to a new physics of stand-off between selfish individualism and altruist collectivism, and an interpretative philosophy where both the adversaries win and both lose [42]. Of course, "this doesn't mean that atomism or reductionism are wrong, but it means that they must be understood in a more subtle and beautiful way than before"; indeed "no one is saying the second law of thermodynamics is wrong, just that there is a contrapuntal process organizing things at a higher level". Just as the advent of quantum mechanics did not signal the demise of Newton, complexity and holism simply ventures beyond the linear pathway of reductionism in

exploring the theme that "the geometry of spacetime is a beautiful expression of the idea that the properties of any one part of the world are determined by its relationships and entanglement with the rest of the world".

Indeed, "the real blow to the idea that the choice of which laws govern nature is determined only by mechanisms acting at the smallest scales came from the dramatic failure of string theory". String theory, "a contender for the theory of everything (TOE), a manner of describing the known fundamental forces and matter in a mathematically complete system", however "has yet to make testable experimental predictions, leading some to claim that it cannot be considered a part of science", seeks to be the supreme manifesto in reductionism in its quest for the ultimate: Matter→Molecule→Atom→Proton/Neutron/Electron→Quark→String. The very strong peer sentiments expressed above, however, lends credence to the possible roadmap of adventure beyond reductionism — do strings represent the genes of Nature? — and ChaNoxity with its mathematically self-contained and consistent view, can provide a global view of the unexplored possibilities that lie beyond reductionism.

This terrain beyond reductionism is synthetic rather that analytic and is distinguished by bumps, block-ades, multifunctions and jumps, contrasted with the ubiquitous uniqueness, smoothness, and continuity of Newton. Negative temperature and specific heat and decreasing symmetry generators of structure, run counter to the established laws of increasing symmetry and entropy that characterize the real world W. The collaborative manifestation of Female $\mathfrak{W}$ on Male W is through the entropy reducing effect of "gravity": this is the source of Schroedinger's neg-entropy and the initiator of the $\mathfrak{W} - W$ homeostasis of life.

Although the New Science does not negate reductionism, its paradigmatic shift in methodology calls for a fresh beginning to proceed beyond its rich analytical legacy. This is easier said than done: the multifaceted inertia can be expected to be not only academic but social, cultural, and political. "In the West, those who hold to a view of a theistic God, including the Christian fundamentalists of such power in the United States, find themselves in a cultural war with those who do not believe in a transcendent God, whether agnostic or atheistic. This war is evidenced by the fierce battle over Intelligent Design being waged politically and in the court systems of the United States. While the battleground is Darwinism, the deeply emotional issues are more fundamental. These include the belief of many religious people that without God's authority, morality has no basis. Literally, for those in the West who hold to these views, part of the passion underlying religious conviction is the fear that the very foundations of Western society will tumble if faith in a transcendent God is not upheld" [23].

The attentive reader has probably not failed to observe that our perception of complexity is in remarkable apparent consonance with that of Irreducible Complexity of "a single system composed of several well-matched interacting parts that contribute to the basic function, wherein the removal of any one of the parts causes the system to effectively cease functioning" [1] leading to the discredited syllogism "Whenever complex design exist, there must have been a designer; nature is complex; therefore nature must have had an intelligent designer" that "everyone understands to be God" [21]. Our explorations beyond reductionism, into the virgin territory of its holistic neighbour, does not advance the inevitability of "creation science" or "scientific creationism" that "is simply not science" because it depends on "supernatural intervention"[14]. The complex entities of Figs. 4, 2a, 5a for example do not appear instantaneously, they evolve in time. Once formed, however, they are indeed "irreducible" in the sense that a disturbance in any of the organs $\bullet - \circ - \bullet$ in Fig. 4 will severely compromise the entire system. As explicated in Looijen [29], the whole is more than the sum of the parts in the sense that the "whole has emergent properties which its component parts do not possess, neither separately nor when simply added together nor in other partial combinations. It is only in the specific combination in which the parts occur in the whole, resulting from their specific mutual interactions, that the emergent properties of the whole appear". In fact the entropic, dissipative, implosive world W is reductionist, the exergic, gravitationally concentrative, explosive world $\mathfrak{W}$ — from its lack of structures and patterns — is holistic, and it is the complexity of $\mathfrak{W} - W$ that represents a respectable "handshake" of the two antagonists: the reductioist W demands that holistic supply $\mathfrak{W}$ rescues it from entropic eventuality in return for its own survival from volcanic exergic concentration.

The most serious bone of contention, however, is likely to be the fundamental notion of competitive-collaboration. That collectiveness is not a mere by-product of selfish individualism as Adam Smith would have us believe [15] is really at the centre of the controversy: selfish individualism and altruist collectivism share a common platform for mutual benefit with neither superseding the other: if Male and Female failed to collaborate, the family would be dysfunctional. Female Capital cannot survive without the cushion of Male

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[14]Unless we interpret $\mathfrak{W}$ to represent the elusive invisible hand of God.

[15]"The supposed omniscience and perfect efficacy of a free market with hindsight looks more like propaganda against communism than plausible science. In reality, markets are not efficient, humans tend to be over-focused in the short-term and blind in the long-term, and errors get amplified, ultimately leading to collective irrationality, panic and crashes. Free markets are wild markets. Surprisingly, classical economics has no framework to understand 'wild' markets. $\cdots$ The recent financial collapse was a systemic meltdown, in which interwined breakdowns $\cdots$ conspired to destabilize the system as a whole. We have had a massive failure of the dominant economic model" [2].

Culture which, in its turn, would starve to death without the supply of essentials by the former. In this world of mutualism, profit as the source of surplus economic energy does not in itself represent stored exergy. The reciprocal feedback of collective culture is indispensible for transformation of entropic profit/benefit to exergic information. In the metaphor of Richard Dawkins [9], collective altruism of the *Selfish Gene* against their own self-interest leads to unselfish action by the organisms, much like the win-win game of Fig. 2*a*, *b*. The gene-centric view of evolution holds that those genes whose phenotypic effects successfully promote their own propagation will be favorably selected in detriment to their competitors, thereby producing adaptations for the benefit of genes and reproductive success of the organism. However, genes not being directly visible to natural selection, the unit of selection is the phenotype: mutational allelic differences in genes generate phenotypes differences — the raw material for natural selection — that indirectly acts upon the genes. The genes are expressed in successive generations in proportion to the selective value of their phenotypic effects, thereby completing the genotype $\rightleftarrows$ phenotype win-win contract. This antagonism of individualistic selfishness and collective altruism are necessary components of this contract.

What is Life? This remarkable query of Schroedinger of 1944 that "must surely rank among the most influential of scientific writings in this century", having led to epochal discoveries subsequently, has been rather difficult to define: the ability to reproduce, often considered a crucial ingredient, would imply for example that a mule was never alive! Considering the non-dead to be alive, however, and taking "dead" as the second law equilibrium state of maximum entropy, far-from-equilibrium complex holism naturally constitutes "life" and hence the "cohabitation of opposites". This is the essence of evolutionary existence in Nature, the apparent defiance of the second law implying an anti-second law arrow that establishes a bottom-up pump competitively collaborating with the second law top-down engine. The universality of this philosophy leads, as we have endeavoured to demonstrate, in a natural way to a comprehensive view of evolutions in Nature.

This abstract and non-specific vision of life emphasises the emergent, self-organizing character of evolving open systems. Availability of exergy embodied in the $\mathfrak{W}$-pump generated by a dissipating W-engine as a defense against its eventual second-law entropic death comprises the sustaining immunity of life: the evolving two-phase mixture of collective cooperating engine and individualistic competing pump induces the top-down-bottom-up homeostasis of the "living".

At the same time in accordance with Sec. 5.1, we must not lose sight of the the significance of the boundary, the "skin" of $\mathfrak{W}$-W, of quantum entanglement. This is a region of linear reductionist first order representation of holism, of near-to-equilibrium phenomena. In this domain of the EPR non-locality of Alice and Bob, non-holistic structures like bacteria, algae and plants need not go through the complex of chanoxity to exist: as demonstrated in Sec. 3.2 a quantum non-local, Punnett square like representation is sufficient for these lower structures. The wondrous manifesto of complex holism establishes itself fully in humans with relatively higher complexity χ (Fig. 3) — reflective of the rigours of competitive-collaboration of the nonlinear qubit — born the most helpless struggling-to-survive infants. The organs must go through a painstaking process of holistic self-organization in W for a long period before attaining functionality — compare with the lesser animals and plants of linear Punnett squares and pay-off matrices distinguished by smaller values of χ, where a new-born is nearly biologically-ready for the intricate maneuvers of existence.

✪ *When you have eliminated the impossible, whatever remains, however improbable, must be the truth.*
Sir Arthur Conan Doyle

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